



United States
Department of
Agriculture

Agricultural
Research
Service

South Atlantic Area
Insects Affecting
Man and Animals
Research Laboratory

1600 SW 23rd Drive
P.O. Box 14565
Gainesville, Florida
32604

904-374-5910

secret
5803

332-3286

YOU'VE BEEN FAXED

FAX NUMBER: (904) 374-5818
(FTS) 947-7818

TELEPHONE NUMBER: (904) 374-5903
(904) 374-5980
5843

IMPORTED FIRE ANTS AND HOUSEHOLD INSECTS
RESEARCH UNITS
USDA-ARS-IAMARL

TELEFAX COVER SHEET

Comisión México-Americana
PARA LA ERRADICACIÓN DEL
Gusano Barrenador del Ganado

MAY 15 1990

Dirección Sección Americana
Km. 2 Carretera a la Angostura
Chiapa de Corzo, Chiapas

DATE SENT: 5/14/90 TIME SENT: 5:30 PM

NUMBER OF PAGES (including cover sheet): 6

TO: DR. C. J. Whitten USDA-ARS-MEXICO
NAME COMPANY/ORGANIZATION

FAX #: 90115296123672 TEL #:

FROM:
NAME OF SENDER

SPECIAL INSTRUCTIONS:



United States
Department of
Agriculture

Agricultural
Research
Service

South Atlantic Area
Insects Affecting
Man and Animals
Research Laboratory

1500 SW 23rd Drive
P.O. Box 14565
Gainesville, Florida
32604

May 14, 1990

SUBJECT: Semio-Chemical Workshop Report

TO: Dr. Al DiMilo Dr. Dave Carlson
Dr. Leslie Hammack Dr. C. J. Whitten
Dr. Robert K. Vander Meer

FROM: Dr. Richard S. Patterson *RSP*

Please read, review and comment on attached report and return by FAX to (904) 374-5818 COMM. or FTS 947-7818 by 3:00 PM, Tuesday May 15th. If your input is not received by then, this will be forwarded as is to Dr. Faust, NPS.

1. Various attractants and pheromones for pestiferous species of man and animals.
 - A. Insecticide - human flies
 - B. Synthetic - insecticide fly pheromones
 - C. Dyes - attractants for control
2. Identification and synthesis of several pheromones in the area.
 1. Queen pheromone
 2. Reproductive pheromone
 3. Nestmate pheromone
3. The role of pheromones as an extremely pheromone has been demonstrated for both sugar and honey bees. Several pheromone compounds, such as 2, 6-dichlorophenol and 2,4-dichlorophenol are known to have effects as aggregation/attraction pheromones. A chemical class has been identified as a common source of pheromones of the American dog tick.
4. Identified the chemical class compound that is a component, along with 2, 6-dichlorophenol and 2,4-dichlorophenol, of a "fecal" extract that when placed over ticks is providing effective control against tick species such as the Lone Star tick and the American dog tick.

Workshop III Applications: Opportunity and Needs (c)

Man and Animals (Acarina, hymenoptera, Diptera and Orthoptera) [ticks, ants, flies, mosquitoes, cockroaches]

Wednesday 1-3 PM

Co-Organizers: R. S. Patterson-C. J. Whitten-Reporter-A. DeMilo

Introduction: Although we have made great progress with little resources in the area of insect semio-chemical and behavior modification chemistry, such as the repellents, pheromone and lures for filth flies, mosquitoes, screwworms, and fire ants; a lot more research needs to be done. Unfortunately little emphasis and support has gone into this type of research on arthropods affecting man and animals in comparison with that done with crop pests. However, we must catch up, as we are fast losing conventional control technologies for these medically important arthropods, and must develop alternative suppression techniques which are environmentally safe if we are to continue to produce sufficient meat and fiber as well as maintain human and animal health in the future at the same level as today.

Accomplishments:

1. Development of repellents such as Deet and its analogues for repelling mosquitoes and various biting flies.
2. Various attractants and pheromones for pestiferous diptera of man and animals.
 - A. muscalure - house flies
 - B. Swamlure - screwworm fly pheromone
 - C. Swass - screwworm attractant plus toxicant for control
3. Identification and synthesizing of several pheromones in fire ants.
 1. Queen pheromone
 2. Recruitment pheromone
 3. Nestmate pheromone
4. The role of guanine as an assembly pheromone has been demonstrated for both argasid and ixodid species. Several phenolic compounds, such as 2, 6-dichlorophenol and O-nitrophenol are known to have activity as aggregation/attachment pheromones. A cholesterol oleate has been identified as a contact mating pheromone of the American dog tick.
5. Identified the cholesterol oleate compound that is a component, along with 2, 6-dichlorophenol and an acaricide, of a "decoy" system that when placed onto cattle is providing effective control against tick species such as the Lone Star tick and the American dog tick.

Current Research*Trapping System*

1. Studies to improve wind-oriented swarmlure traps and other bait stations for potential use in developing countries in Central America and North Africa.
2. Isolation and characterization of screwworm wound attractants.
3. Laboratory and field behavior studies of screwworm wound materials that act as attractants.
4. Isolation of screwworm mating-stimulant pheromone (female produced).
5. Synthesis and development of candidate carboxamide-derived repellents for cockroaches, ticks, mosquitoes and other biting flies and investigation of structure-activity relationships.
6. Studies in the behavior and population dynamics of cockroaches and development of strategies for utilization of attractants and repellents for management of their populations to study harborage and movement of these urban pests.
7. Behavioral characterization of fire ant recruitment and queen pheromones in order to develop better fire ant baits that are species specific and environmentally safe.
8. Studies to characterize the source and composition of recruitment and queen pheromones in fire ants.
9. Characterization of fire ant attractants in vegetable oils (soybeans, olive oil).
10. Studies on the characterization of what semio-chemicals are given off by humans which attract mosquitoes and biting flies.
11. Studies on the characterization of sex attractants and sex stimulants of *Ixodes* spp. and other ticks.
12. Development of repellents for the fire ant.

RESEARCH OPPORTUNITIES AND NEEDS (ARTHROPOD PESTS OF MAN & ANIMALS)

There are numerous opportunities on semio-chemical and behavior modification chemistry that could provide more efficient control technologies for the suppression of arthropods affecting man and animals. These are:

1. Team research. We need more flexibility in ARS for interdisciplinary research between and among ARS scientists and locations plus between university members and ARS. Because of CRIS accountability, this is difficult for short term programs. For example, research such as single cell/electro antinograms capabilities of pest affecting man and animals is needed but must be a cooperative effort.
2. Better biological and chemical support for these programs, so that definite goals can be met in a timely manner. These include species specific baits in fire ants, attractants for determining infestations and population levels with ants, cockroaches, biting and pestiferous flies, mosquitoes, ticks, etc.
3. To examine the potential of plant extracts as arrestants, attractants, and repellents of blood feeding insects.
4. Definition of host odors to determine host specificity for arthropods attacking man and animals.
5. Volatiles of pheromones for trapping systems of biting diptera for monitoring and control.
6. Use of pheromones or semio-chemicals to increase the efficiency of parasitoids and predators which attack pests of man and animals.
7. Increased emphasis on chemical structural activity relationships in order to develop better and safer repellents for biting diptera and cockroaches.
8. Determination of dosage and formulation response of attractants, pheromones and repellents of individual semio-chemicals by arthropods affecting man and animals.
9. Field evaluation of semio-chemicals and behavior modifiers, so that the products can be transferred to the general public. Simulated models to determine potential impact of these chemicals on control programs.
10. Pheromones in combination with host-associated chemicals that elicit host-finding behavior could possibly be used in bait-toxicant systems to control the off-host stages of tick species that seek hosts actively. While early efforts to use

aggregation pheromones in systems to effect control of ticks on livestock failed, increased knowledge of the array of pheromones that influence mating behavior of ticks could be the basis for the development of practical, cost-effective, and environmentally safe methods for the control of ticks. Additional research is needed on tick pheromones and their possible use in new methods for control before this avenue for the development of new control technology is abandoned.

YOU'VE BEEN FAXED

FAX NUMBER (904) 374-5818
(772) 477-8118

TELEPHONE NUMBER (904) 374-5803
(904) 374-5800

IMPORTED FIRE ANTS AND HOUSEHOLD INSECTS
RESEARCH UNITS
USDA-ARS-IAMARI

TELEFAX CONTROL SHEET

DATE SENT 5/18/90 TIME SENT 5:31 PM

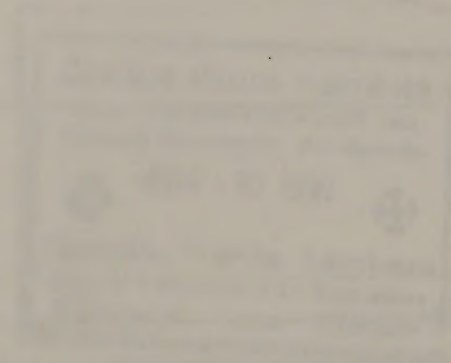
NUMBER OF PAGES 6

TO: DR. J. S. G. (904) 374-5818
FROM: USDA-ARS-IFAH

FAX # 904 374 5818 TO #

FROM: NAME OF SENDER

REMARKS/REMARKS





United States
Department of
Agriculture

Agricultural
Research
Service

South Atlantic Area
Insects Affecting
Man and Animals
Research Laboratory

1600 SW 23rd Drive
P.O. Box 14555
Gainesville, Florida
32604

YOU'VE BEEN FAXED

FAX NUMBER: (904) 374-5818
(FIS) 947-7818

TELEPHONE NUMBER: (904) 374-5903
(904) 374-5980

IMPORTED FIRE ANTS AND HOUSEHOLD INSECTS RESEARCH UNITS USDA-ARS-IAMARL

TELEFAX COVER SHEET

DATE SENT: 5/14/90 TIME SENT: 5:30 PM

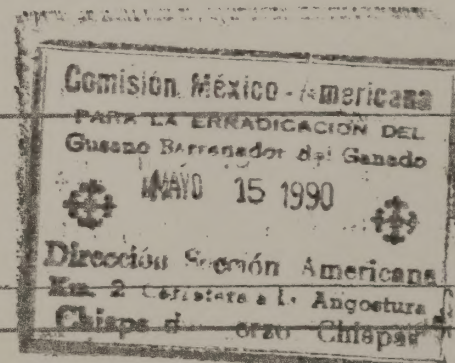
NUMBER OF PAGES (including cover sheet): 6

TO: DR. C. J. Whitten USDA-ARS-MEXICO
NAME COMPANY/ORGANIZATION

FAX #: 90115296123672 TEL #:

FROM: _____
NAME OF SENDER

SPECIAL INSTRUCTIONS: _____





United States
Department of
Agriculture

Agricultural
Research
Service

South Atlantic Area
Insects Affecting
Man and Animals
Research Laboratory

1600 SW 23rd Drive
P.O. Box 14565
Gainesville, Florida
32604

May 14, 1990

SUBJECT: Semio-Chemical Workshop Report

TO: Dr. Al DiMilo Dr. Dave Carlson
Dr. Leslie Hammack Dr. C. J. Whitten
Dr. Robert K. Vander Meer

FROM: Dr. Richard S. Patterson *RSP*

Please read, review and comment on attached report and return by FAX to (904) 374-5818 COMM. or FTS 947-7818 by 3:00 PM, Tuesday May 15th. If your input is not received by then, this will be forwarded as is to Dr. Faust, NPS.

Schwalbe Monitoring

(1)

5/9/90

- Gypsy Moth 300,000 Traps/yr
- Areas categorized into area of differing risk
 - For detection survey
 - h₁ risk 1 trap/sq mi
- Assumption - moths are caught near to site of emergence
- When detected, a more extensive trapping network is used to delineate infestation

Hypergeometric distribution

For detection

$$n = -(N/x) \times \ln(1-p)$$

(acres, animals, etc)

N = # of units to be surveyed

x = # of " infested

p = probability of detection

n = # of traps

Summary Science

- Bio regulation
 - neuro regulation
 - P-bands?
 - Perception
 - reception of semiochemicals
 - Chemistry
 - Insects { Granlure & Japanese beetle
 - lure systems are marketed
 - Semiochemicals for tick control
 - needs to be investigated
 - Plants - Resistance in plants to pests
 - Needs - Modelling
 - Behavior
 - Heliothis v. ♂♂ emit pheromone to elicit response from ♀♀
 - LEARNING behavior in Micropletes (Hopkins Host Principle?)
 - Population Dynamics
 - Attractants for Area-wide program
-
- Technology
- Delivery System
 - Predictive models are available for slow release systems
 - Monitoring
 - Intendisciplinary cooperation

Mass Trapping

Mating Disruption

Research decreasing?

- Interdisciplinary cooperation

Semiochemical

Plants - developed resistant plants

Applications

- Crop Pests

- Colorado potato beetle attractant
not available

- Fruit flies

Behaviour - Trapping &
male annihilation
- Team work

- Stored Product Pests

- Man & Animal Pests

- Beneficial Insects

- Bees

- Parasites & predators

- need in vitro rearing

" colony management
in terms of quality,
genetics

EPA Registration for Biologicals

280 days target for registration

Hazard

$$\text{Exposure}^+ \text{Opportunity} = \text{Risk}$$

Hazard Data

- Product Analysis

Toxicity Data

Toxicity (Acute)

Sensitivity

} also on nontarget
organisms

Experimental Use Permit
(IO ALRES)

Reregistration of pesticides registration
pre Nov 1984

Demonstrated Accomp

Current Res.

Needs & opportunities

Semiochemicals for biting
flies

Detection

Monitoring

Collection for research

Suppression

SWASS

CURACAO

U.S. , Mexico

Lybia

Potential

Oviposition

Artificial wound

5/9/90

Repellents

— mosquito
Biting flies

Hydroxyesters

DEET

— Cockroach
tactile action
attractants

5/9/96

Ticks

- CO_2
- Chlorinated phenol produced by ticks - short range

Flies (biting)

- CO_2 1-2 Ltrs/min required
- Octenol (1-octen-3-ol)
- Lactic acid
- Phenolic derivatives present in cattle urine
- Sex attractants - short range
- Food attractants - plants & flowers

Parasitoid wasps

- Host volatiles

Filth Breeding flies

5/9/90

Fire Ant

- Bait - soybean oil
- 3 component queen
pheromone
- worker produced pheromone
attraction
- repellents
- non pheromone attractant
soybean oil

Monitoring ②

5/9

Modeling in gypsy moth
GIS system

5/9/90

Mass Trapping/Baits

Pink Bollworm

mass trapping for 863

probably not effecting

Vegetable insects

Bank beetles

John Bonden

Forest Insect

9 traps/acre

Gypsy moth

5/8/90

Semiochemical — Form on
Workshop background
to Heath

Mellingen

Leaf miners on celery (Tingard &
insecticide resistance
" " on tomatoes (Avermectin)

Sweet Potato white fly
on tomatoes cause irregular
ripening

Fall armyworm
on corn

Pepper weevil

(methamidophos?)

Diamond-back moth -
on cabbage

Carde

Phenomane Production

PBAN

TAB - terminal abdominal
ganglion

Source



20

40

80

120

(2)

5/8/90

Meteorological variation
affects response

a lot of pheromone goes
downwind without being
diluted too much.

Principal Component Analyses

(1) velocity

(2) steering

(3) " feedback

(4) oscillator

Gypsy moth has a simple
single
chemical system

Pemphredon (do not receive
lower concentration)
False Trail
Camouflage to plum

(3)

5/8/90

learning in gypsy moth
pupal parasite?

— Cutler Plant chemistry
(technocracy)

$\alpha + \beta$ DVT diols from tobacco

Nature doesn't waste
energy,
man does.

DIMBOA - increases
in wheat reproductive
cycle

Aspergillus niger
produce nigerazine A & B
have plant activity

5/8/90

(4)

- streptomyces
L-alanine
similar to Roundup
in environment affected
in melting

- from ferns
sarmendalactone
feeding inhibitor

Peter Price
Population Ecology
In a 3 trophic system

bottom driven -
host resources
control system
top driven -
control exerted by
parasites

5/7/90

Objectives

- 1 Improve Communications linkages etc
- 2 Current status
- 3 " needs

cover needs & opportunities
in final oral reports

(5)

5/8/90

Tue PM

Behavior

Pete Landolt

- research scope
- open mindedness
- need to go back to basic
- ethologically oriented
-

First

Know what behavior is in field

Then bioassay

Arita Collins

2-decanoic acid analogs
honey bee pheromones

isopentyl acetate - alarm
pheromone

(6)

5/9/90

Bill Steiner

Genetics of behavior
in microples

- oviposition

- antennal response

Broad categories of control of behavior

- genetic variation

- learning

- physiological status

needs

- Team research

- neuropeptides - internal controls

- disseminate information

(7)

5/9/90

Population Dynamics

Problems

1. Sex attractant specific
for σ_5
2. Pheromone blends
3. Trap efficiency

Problems of dev models

- ① weather patterns
- ② Host diversity, availability
maturity etc.
- ③ Density of natural enemies
- ④ Competing species

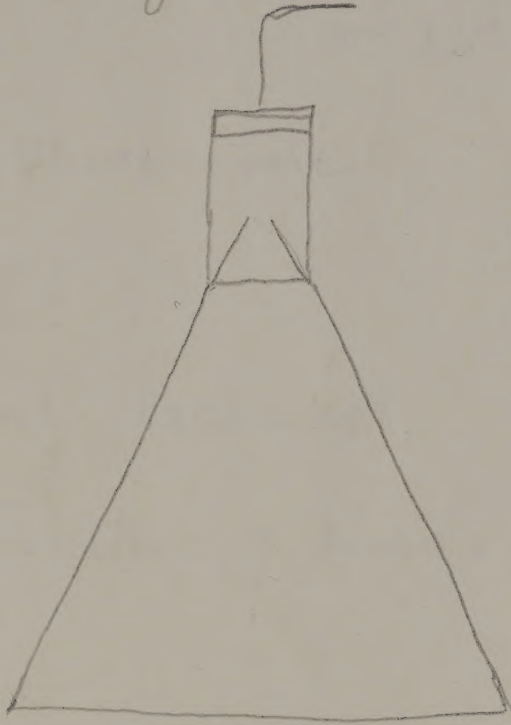
Old ideas

- ① Sex attractants are ~~sex~~ specific
- ② Need more female attractants to:
 - population modeling
 - development of alt control
strategies

(8)

5/9/90

Trap for Heliothis



- Timing
- number
- Composition

⑨

5/9/90

1

25 traps/mi²

in gypsy moth

phenomone

Accomp

Current Research

- Opportunities & Needs

1



United States
Department of
Agriculture

Agricultural
Research
Service

Program
Aid 1445

Solving Agricultural Problems With Biotechnology



Cover

At the Agricultural Research Service's Plant Gene Expression Center in Albany, California, a postdoctoral research associate separates large DNA fragments on a pulsed field electrophoresis apparatus. The goal of this work is to establish a physical method of isolating male sterility genes.

Contents

Biotechnology Defined	1
ARS Research Areas Using Biotechnology	2
Biotechnology Research	4
Monoclonal Antibodies	5
DNA Hybridization and DNA Probes	6
Recombinant DNA	7
Gene Mapping and Sequence Analysis	8
Tissue Culture	11
Gene Transfer	12
Protoplast Fusion	19
Biochemical Engineering	19
Bioregulation	22
The Plant Molecular Biology Laboratory	10
Getting Soybeans To Grow	16
The Plant Gene Expression Center	21

Mention of a commercial firm in this publication is not an endorsement by the U.S. Department of Agriculture over other firms not mentioned.

Solving Agricultural Problems With Biotechnology

*by the Biotechnology Matrix Team of the National Program Staff,
Agricultural Research Service, U.S. Department of Agriculture*

Modern biotechnology creates unprecedented opportunities to study and understand basic life processes and to modify and regulate them precisely with a range of techniques that were undreamed of a generation ago. The potential of biotechnology in medicine has received much attention, deservedly so. Just as important to the future prosperity of civilization is the potential for advances in agriculture.

Biotechnology promises to improve agricultural productivity; decrease our dependence on potentially harmful chemicals—pesticides, fertilizers, and antibiotics; improve safety and quality of agricultural products; decrease our dependence on petroleum as a basis for plastics and industrial chemicals; and enhance our ability to produce food on marginal lands.

The Agricultural Research Service (ARS), principal research agency of the U.S. Department of Agriculture, is a world leader in using biotechnology to help solve the increasingly complex problems of today's agriculture.

The ARS biotechnology toolbox includes every known method for investigating and manipulating organisms at the molecular level and some methods that ARS scientists are developing to meet the particular needs of their research missions. These tools encompass a broad range of new and traditional techniques.

Biotechnology Defined

ARS is a Federal research agency with various kinds of accountability and strictly adheres to established environmental regulations and biosafety guidelines in its research, especially when it comes to the production of new or changed organisms. The agency defines the term "biotechnology" as the "use of living organisms, cells, subcellular organelles, and/or parts of those structures, as well as the molecules, to effect biological, chemical, or physical changes." In ARS, this accounts for more than 54 million dollars (10 percent) of the budget for research.

ARS Research Areas Using Biotechnology

The ARS mission is to solve technical food and agricultural problems of broad scope and high national priority in conservation of natural resources, crop production and protection, animal production and protection, postharvest quality and use, human nutrition, and integration of agricultural management systems. Biotechnology has a larger role in research on field and horticultural crops, livestock, and postharvest technology than in the other areas, but it is also used in research on human nutrition and resource conservation. In these five areas, ARS conducts biotechnology research to help in—

Conservation of natural resources

- Reducing and eliminating effects of natural and artificial pollutants in soil and water.
- Adapting plants to marginal growing conditions.

Crop production and protection

- Developing cereals, forages, fiber crops, and fruits and vegetables that are—
 - Highly adapted to environmental stresses such as drought, cold, heat, and toxic soil minerals.
 - Tailored to have the best possible quality in essential nutrients and other desirable attributes.
 - Able to fix (convert to usable form) atmospheric nitrogen, minimizing the need for adding nitrogen fertilizer.
- Increasing plant resistance to diseases, insects and other arthropods, nematodes, weeds, and other pests.
- Using biochemical and genetic engineering to enhance the effectiveness of beneficial insects, parasites, viruses, bacteria, and other biological and biologically based methods of controlling plant pests.

Animal production and protection

- Developing more effective diagnostic tests for costly diseases of beef and dairy cattle, pigs, sheep, chickens, and turkeys.
- Producing new and more reliable preventive measures against livestock diseases.
- Improving the effectiveness of biocontrol organisms, or their products, used against livestock insects, ticks, and other pests.

Postharvest quality and use

- Improving the safety and quality of processed and unprocessed foods.
- Enhancing nonfood uses of farm products to increase their market value.
- Developing new uses for farm products, especially those often producing surpluses.

Human nutrition

- Determining just what nutrients the human body needs in what amounts and combinations.

Management systems

Though not, of course, actually using biotechnology tools, ARS systems researchers are involved in biotech research. They're developing management systems to handle the enormous quantities of data being generated in biotechnology work. These include integrated data systems—such as information on gene banks—and mathematical modeling of such factors as weather, genetic makeup, and physiology to enhance plant and animal growth.

Cleaning Up Soil With Tailored Bacteria



At the ARS Pesticide Degradation Laboratory in Beltsville, Maryland, a microbiologist checks petri dishes in which he's growing bacteria that have been genetically engineered to enhance their natural ability for breaking down toxic wastes. Genes that encode enzymes that degrade certain pesticides were cloned from the DNA of two soil bacteria—*Achromobacter*, which degrades carbofuran, and *Flavobacterium*, which speeds up degradation of coumaphos. Carbofuran and coumaphos are potent insecticides; the more rapidly they can be broken down, the less likely they are to seep into soil and groundwater. (0386X501-35)

Biotechnology Research

Scientists use biotech tools to study, manipulate, and modify specific organisms. Most of the techniques described in this book can be used for both diagnosis and manipulation. And biochemical engineering and bioregulation research are biotechnologies that use many of the individual tools.

What follows is an overview of ARS biotechnology research with examples of ongoing projects and recent accomplishments. Detailing all the techniques and all the projects isn't possible here. For further general program information, call or write:

Chairperson, Biotechnology Matrix Team
Agricultural Research Service, USDA
Room 236, Bldg. 005, BARC-West
Beltsville, MD 20705
Phone: (301) 344-3918



A commercially produced trichinosis test kit based on ARS research using monoclonal antibodies.
(88BW0063-6)

Technical information on current and recently completed research projects is available through CRIS (Current Research Information System) Online, a database accessible through Dialog Information Services, a commercial retrieval service. Many libraries, including the National Agricultural Library in Beltsville, Maryland, will do CRIS searches, often for a fee. The CRIS database includes abstracts, scientist names and locations, and lists of recent publications on nearly all current agricultural and forestry research funded in whole or part by the Federal Government. It is also published on commercial CD-ROM disks that may be available for use at some institutional libraries.

ARS has its own online database, called TEKTRAN. Subscriptions are offered on a first-come-first-served basis to organizations (such as commercial firms, universities, and government agencies). The research results described in the TEKTRAN database have been peer-reviewed but not yet published. To ask about access to TEKTRAN, call the ARS National Technology Transfer Coordinator at (301) 344-4045.

Monoclonal Antibodies

Monoclonal antibody technology is used to produce large amounts of nearly identical antibodies, which can single out specific antigens (chemicals or microorganisms that stimulate antibody production).

ARS scientists are developing and using monoclonal antibodies as basic research tools in several kinds of projects, such as the discovery, study, and enhancement of biocontrol agents; study and manipulation of plant bioregulation mechanisms; and especially the detection of organisms that cause plant and animal diseases, location of specific proteins, and development of vaccines that capitalize on the animal's immune-system response and are more specific than traditional (trial-and-error) vaccines.

Diagnostic tests for plant and animal diseases

One of the more useful features of monoclonal antibodies is that they "recognize" specific immunogens, substances that trigger immune responses. If an immunogen is present, the monoclonal antibody should find it. So developing monoclonal antibodies to immunogens associated with a particular disease is a means to a highly specific method of disease diagnosis.

In 1984, an ARS parasitologist in Beltsville, Maryland, used monoclonal antibodies to develop a blood test that is 90 percent accurate in detecting trichinosis in pigs. (Trichinosis is caused by the

parasitic trichina worm; in the United States, only about 1 in 1,000 pigs is believed to be infected, and humans can avoid contracting the disease by adequately cooking or freezing their pork.)

The test was originally developed as a research tool to be used in projects aimed at eliminating trichina infections in domesticated swine in the United States. But the test had obvious commercial applications as well; the technology was patented and then transferred to several firms through licenses and cooperative research agreements. Commercial diagnostic kits, based on refinements in the original test, are now available for testing pigs on the farm or at the slaughterhouse.

Other diagnostic tests resulting from ARS research with monoclonal antibodies include:

- A test for active neutrophils (a kind of white blood cell) in cattle. Cattle with active neutrophils have greater disease resistance and could be used to produce more disease-resistant breeds.
- A broad spectrum diagnostic kit that will quickly detect some of the world's most damaging viruses to plants in one test. Being marketed by a commercial firm, the kit is based on an ARS-developed monoclonal antibody (patent applied for) that reacts to a site on a protein molecule common to most, if not all, potyviruses. Named after potato virus Y, potyviruses affect many important crops, including corn, soybeans, wheat, lettuce, and other vegetables and ornamentals such as tulips and Easter lilies. Seed-testing firms, nurseries, farmers, and government agencies that quarantine plants are among the kit's potential customers.

Like the trichinosis test kit, many of these diagnostic tests are offshoots of research aimed at learning more about immune response and the processes of disease development so that scientists can enhance disease resistance through genetic engineering, breeding, and other means.

DNA Hybridization and DNA Probes

DNA—or deoxyribonucleic acid, and RNA—ribonucleic acid—are molecules made up of chains of nucleotide bases. The sequence of these bases on the chain is the information governing an organism's form and biology.

DNA is usually double stranded; the nucleotide bases in one strand are bonded with complementary nucleotide bases in the other, forming base pairs. RNA is usually found as a single chain. A DNA molecule's two strands can be separated, and an RNA strand can bond with one of these separated DNA strands.

DNA can be cloned, separated into single strands, or labeled with radioactive isotopes or other markers. Researchers can also synthesize DNA complementary to the DNA they're interested in and use it as a detection probe. Complementary DNA, or cDNA, is produced from an RNA sequence, usually messenger RNA, using an enzyme called reverse transcriptase. RNA fragments can also be used as probes in work with nucleic acid hybridization.

The hybrid of the DNA/DNA or DNA/RNA strands may be joined along the entire length of the strands, or only partly, depending on the match of the individual nucleotide bases. How much the cDNA strand and its complement match can tell scientists a great deal about, for example, how closely related two species happen to be or the locations of particular genes.

Like monoclonal antibodies, DNA probes are used as diagnostic tools in many research projects directed at understanding and eventually controlling basic biological processes in crop plants and farm animals and in the pests and diseases that diminish their economic value.

And as with monoclonal antibodies, ARS research with DNA probes has led to more accurate diagnostic tests for certain animal diseases—leptospirosis, which causes abortions in cows, and anaplasmosis, which infects red blood cells in cattle, causing anemia. Similarly, ARS plant pathologists and geneticists have developed several diagnostic tests using DNA probes to detect viruses and viroids that cause plant diseases such as potato spindle tuber disease.

Recombinant DNA

Molecular biologists construct recombinant DNA molecules by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell. The result is a new genetic combination. Recombination occurs naturally; it is the key to genetic diversity. But of the billions of recombinations that occur in nature each day, few are successful and even fewer have a practical value. Laboratory recombination controls and channels this natural process.

Recombinant DNA technology can be used as a diagnostic tool and as a means for creating specific vaccines. In one project, ARS researchers are using it to develop vaccines to protect cattle against cattle grubs and other arthropod pests. Such a vaccine is being tested now; if successful, it would be the first recombinant DNA vaccine to protect an animal against an insect pest.

Gene Mapping and Sequence Analysis

Gene mapping determines how genes are arranged on a chromosome. ARS scientists are mapping genes for several organisms as part of genetic studies essential to sophisticated cross-breeding of plants and animals.

Especially useful tools for mapping genes are restriction enzymes. Because they cut DNA strands at predictable places, restriction enzymes are commonly used to create DNA restriction fragments. A restriction fragment is a piece of DNA cut by a restriction enzyme. A given type of fragment that often varies in length in the population (a "length polymorphism") defines a genetic variable. This information is particularly helpful if the restriction fragment length polymorphism (RFLP) is associated with observable differences in the organisms—such as susceptibility to disease. The techniques can be used for specific identification or differentiation of closely related microbes such as pathogenic variants.

Just one ARS-developed example of the potential of this biotechnology: Using restriction enzymes, researchers can now distinguish clearly and reliably between two look-alike species of sugarcane—*Saccharum sinense* has an additional fragment of DNA that's not found in *S. barberi*. Accurate identification of the two species is critical because they're among the six used today in producing commercial sugarcane varieties.

Knowledge gained from gene mapping can be combined with the knowledge gained from sequence analysis to give scientists much of the information they need to understand and improve a given organism. Analysis of the sequence of nucleotide bases in a particular segment of DNA gives genetic engineers a vocabulary to work with in manipulating the genetic "sentence." For example, ARS researchers at Albany, California, and colleagues in England have sequenced the DNA of two genes thought to be responsible for high-quality flour. These genes direct production of special glutenin proteins usually found in superior flour. This knowledge will be used to help improve the genetic makeup and therefore the breadmaking quality of wheat varieties.

ARS research projects using gene-mapping tools and sequence analysis range from identification and enhancement of biocontrol agents to improving diagnosis and treatment of plant and animal diseases.

One project is using gene mapping to define more precisely the genetic differences among certain insect pests of field crops (especially corn earworm and tobacco budworm and related species). Better knowledge will lead to more narrowly focused control measures, which will be more effective than current methods and less likely to damage the environment.

Gene mapping is also an important component of modern plant breeding research. ARS scientists are using information about the locations and relationships of specific genes to improve germplasm of, for example, soybeans, corn, tall fescue, and barley.

In mapping genes, scientists are learning more about what makes living things work. Most crop plants and livestock animals are genetically complex, and it will probably be many years before their genetic mechanisms are completely understood. So the most immediate payoffs are likely to come from work with simpler organisms.

ARS researchers, for instance, are using gene mapping to gain practical information about plant pathogens—organisms, such as bacteria and viruses, that cause plant diseases. Studies are concentrating on the genetic factors that determine a pathogen's virulence, or capacity to actually cause the disease, and its ability to resist antibiotics.

Another project involves DNA sequencing of genes responsible for lysine synthesis in rice; the goal is to increase production of this nutritionally essential amino acid in various cereal crops.

Genome mapping project

Whatever the technique, whatever the immediate goal, gene mapping and sequencing contribute to a complete picture of an organism's genetic makeup, or genome.

But while many mapping projects are now being carried out by Federal, State, university, and industry researchers, there has been no single major project to develop complete gene maps of the important food, fiber, industrial, and forest crops.

Yet knowledge about the genomes of these crop species is essential. We need to know the location of genes that control or influence yield, time of maturation, nutritional content, and resistance to disease, insects, and drought so that we can continue to improve crops.

To achieve this goal, the Secretary of Agriculture, Clayton Yeutter, announced, in early 1989, plans for a plant genome mapping program—a major research effort to identify the most important genes present in the major food and forest crops and to determine what the genes do and how they function. ARS has been assigned responsibility for leadership in developing the plant genome mapping project. The agency will act as a focal point for a system of interrelated Federal, State, and university research that contributes to this project.

The project is likely to be even more complex than the human genome study recently begun because of the number of plant species involved. Corn alone has about the same number of nucleotide base pairs as human chromosomes—3 billion.

ARS scientists at Raleigh, North Carolina, have already made a start on mapping the corn genome. They are mapping the genes of higher yielding corn by tagging corn chromosomes with previously identified DNA sequences.

The Plant Molecular Biology Laboratory

The Beltsville (Maryland) Agricultural Research Center is the largest complex of laboratories, scientists, and support staff in ARS, making it the most prominent center of agricultural research in the world. Since its beginnings in 1910, Beltsville has contributed greatly to the continuing prosperity of American agriculture and the well-being of people everywhere, from genetic concepts that laid the foundation for modern plant and animal breeding to the creation of a standardized reference diet for use as a research tool in human metabolic studies, from developing the Beltsville Small White turkey to identifying and supplying disease-resistant wheat to plant-breeding centers around the world for the Green Revolution (a turning point in agriculture that drastically reduced world hunger).

Two of the most notable accomplishments at Beltsville came in plant biology—discovery and isolation of phytochrome, the photoreceptor that regulates many plant growth and development responses to light, and discovery and isolation of plant viroids, a new class of disease-causing particles 80 times smaller than viruses. The laboratories where these discoveries were made are the ancestors of the recently established Plant Molecular Biology Laboratory, which was installed in April 1989 in a newly remodeled and modernized building at the Beltsville center. The goals of the new lab are to identify and isolate genes that control plant metabolism, to develop reliable tools for transferring the genes, and to find ways to regrow resulting transgenic plants. Recent research accomplishments include a tissue-cultured rice with high lysine content (which leads to more and better protein) and development of a technique to transfer genes into pollen by electroporation—using split-second electric shocks to open pores in the pollen that allow entry of new genes. Other accomplishments include tissue culture of peach trees (see p. 12), in vitro root production of soybeans (see p. 16), and transfer of a corn storage protein enriched in sulfur amino acid content (see p. 13).



Tissue-cultured strawberry plantlet is one of many horticultural crops cloned to be free of disease-causing organisms and to be extra vigorous. (0386X429-25a)

Tissue Culture

Use of tissue culture enables scientists to grow the early stages of an organism in a laboratory environment. The organism is grown *in vitro* (literally “in glass”). “Tissue culture” is a general term covering all forms of *in vitro* culture: The organism can be started from tissue (an aggregate of similar cells) or from a single cell, from an embryo, and from other sources such as the anther (part of the male reproductive organ in plants) or from a specific insect tissue.

Tissue culture techniques include use of specific growth media, temperature, and other physical requirements. These techniques enable mass production of near-identical clones, a necessity for biotechnology research and applications.

Having near-identical clones is particularly useful in breeding improved crop and horticultural plants. Current ARS research using tissue culture in improving plant germplasm includes work with alfalfa, sunflowers, oats, forage and turf grasses, cotton, rice, corn, sugar beets, sugarcane, lettuce and other leafy vegetables, sorghum, wheat, and fruit trees such as apples and peaches.

ARS scientists are also using tissue culture to develop reliable laboratory lines of insect cells. The main uses of such cell lines are for study of basic biological factors governing insect growth and metabolism and behavior (so that researchers can manipulate these factors to control pest insects) and for factorylike production of viruses that can be used as biocontrols. Certain constituents of insect viral DNA are being used to produce medical and veterinary vaccines and human hormones in tissue culture.

Increasing profits with tissue-cultured fruit trees

Tissue culture is also a commercially practical means of propagating plants rapidly, uniformly, and free of disease, without climatic and seasonal restrictions. Scientists at the ARS Beltsville Agricultural Research Center in Maryland have solved the major problems of tissue-culturing peach trees. Trees from small shoots raised by tissue culture bore 10 times more peaches in their second year than conventionally grafted trees. Normally, peach trees need 3 years to begin producing a cash crop. But 2-year-old tissue-cultured, own-rooted trees produced 285 peaches per tree, compared with 33 peaches on trees grafted onto seedling root stocks. Eventually, the two types of trees will produce similar yields, but a sizable second-year crop would increase the orchard grower's profits. Beltsville scientists have also overcome the difficulties in getting roots started for tissue culture of apple trees; now focus has shifted to the less difficult but equally important problems of shoot formation.

Gene Transfer

In theory, since a gene is just a piece of DNA—chemical compounds bonded together and arranged in a particular sequence—it can be moved from one organism to another by means of one of many gene-transfer techniques. In fact, ARS scientists have transferred foreign genes into both plants and animals. These genes have produced their particular characteristics (expressed themselves) in the resulting plants and animals and in many of their offspring. The technical difficulties can be enormous, though they are being solved. And in some cases, scientists must use extraordinary precautions to ensure the safety of this research.

The potential payoff is also enormous. One, the years it takes to introduce genetic improvements through traditional breeding could be reduced to a fraction of that time. Two, genes can be transferred not only within species, but among them: An ARS scientist at Beltsville, Maryland, was the first to succeed at microinjecting foreign chromosomes into single plant cells. The result was a petunia with new

drought-tolerance genes that improved the plant's ability to withstand water stress. (Petunias were used for this basic study because they can be grown in the lab from a single cell; see p. 16.)

Researchers are using gene-transfer techniques to enhance effectiveness of biological agents that help control pests of animals, crops, and stored fruits. Other scientists are using gene-transfer techniques to improve the ability of certain food-processing organisms to reduce cholesterol levels in processed foods containing dairy ingredients. And various research projects are using microinjection and other gene-transfer techniques to study and improve wheat, oats, rice, and other cereals. This work is concentrating on resistance to insects such as greenbug, yellow sugarcane aphid, and the Russian wheat aphid; to diseases, especially virus diseases of wheat; and to drought.

Gene transfer can also be used to improve a plant's nutritional quality. For instance, soybeans and other legumes will provide a more complete source of protein when a corn gene enriched in sulfur amino acid content can be engineered into the crops. Legumes are usually very low in sulfur-containing essential amino acids. As a start, ARS scientists at Beltsville, Maryland, in collaboration with scientists from Agrigenetics Basic Science Corporation, found that when one of corn's storage proteins is inserted into tobacco plants, the tobacco seeds synthesize and store the storage protein enriched with sulfur amino acids. Tobacco is being used as a model because scientists haven't yet succeeded in regenerating seed-bearing soybeans from genetically engineered cells (see p. 16).

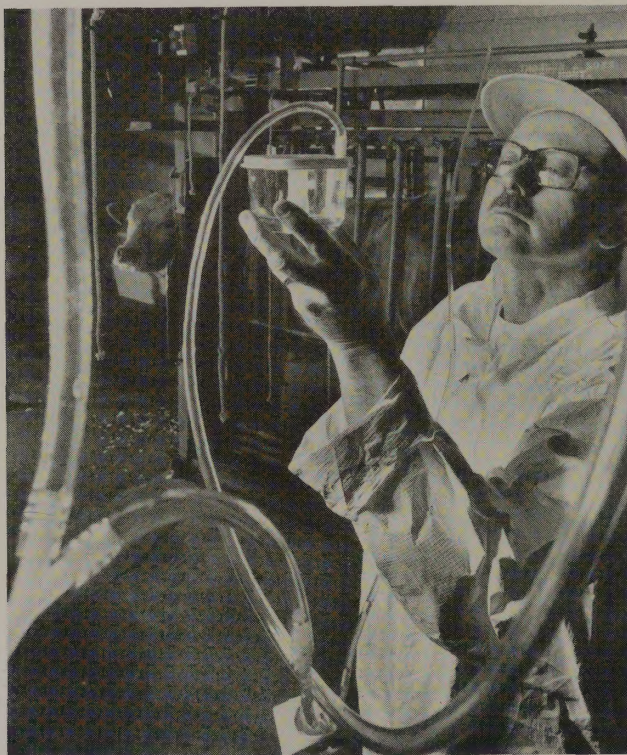
Transgenic plants are more likely than transgenic animals to be commercially available on a large scale in the near future. Gene transfer studies in animals involve ethical considerations not usually applied to plants. But releasing transgenic plants into the environment also raises some concerns that are addressed in careful review case by case.

Shortcuts to breeding better, healthier cows

Finding out, for example, whether a gene inserted into an animal embryo will take hold has to wait on the actual birth. In cattle, the wait is about 280 days. ARS scientists at Beltsville, Maryland, have used a gene-copying system that will cut this waiting period to less than 2 weeks. The new system, successful in mice but designed for future use in cattle, will save genetic engineers a great deal of time. Five to 7 days after scientists have injected a new gene, they will split the embryo into identical twins. One twin embryo will be used for the gene-copying technique, in which as few as 25 of its cells are mixed with the enzyme Taq polymerase. If the injected gene is present, the

Taq polymerase makes a million or more copies of the gene—enough for standard tests to determine its presence. If the result is positive, the scientists will implant the other twin into a surrogate mother cow.

Embryo transplants will also help scientists overcome a big obstacle to breeding disease-resistant cattle—lack of cattle with the same immunity genes for use in research. Today those genes—collectively called the major histocompatibility complex—can be studied in inbred rodents, where rapid reproduction allows relatively quick gene manipulation. Since the same approach in cattle would take 40 to 100 years, Beltsville scientists are using the split embryo technique to decrease the time. Results so far include twin sisters and a bull from the same biological mother with the same genes over most of the histocompatibility complex. When the sisters are bred to the bull, 25 percent of the offspring should have identical genes for immunity. Those offspring will be pioneer sources for cattle with genetic resistance to diseases such as stomach worm, foot-and-mouth disease, and bluetongue.



ARS animal physiologist flushes 7-day-old embryos from a cow treated with a hormone that induces multiple ovulation. Recovered embryos are implanted into surrogate mothers or frozen for later use. Ability to store and transplant animal embryos is essential to many gene transfer studies. (88BW0902-4)

A new breed of chickens

Transgenic chickens that can resist avian leukosis virus have been bred by ARS scientists at East Lansing, Michigan. Avian leukosis costs U.S. egg producers \$50 to \$100 million a year. But it happens that the virus that causes avian leukosis is one of a class of viruses—retroviruses—that can be used to transfer genes. Retroviruses are different because their gene code is contained in their RNA rather than in DNA. Once inside a cell, a retrovirus releases an enzyme that converts its RNA to DNA. The DNA seeks out the cell's genes and merges with them. The cell then produces a new virus particle.

Eventually, retroviruses could be used to transfer genes for various traits: In chickens this could mean less fat, better taste, and ability to grow larger on less feed. But preliminary work has centered on giving chickens an inheritable resistance to the avian leukosis virus itself. Genes were transferred from a strain of the virus that seldom causes avian leukosis. In hundreds of attempts to transfer the virus genes, scientists squirted virus through the eggshell near the day-old embryo and then hatched the egg. Transgenic chickens bred from one of these embryos are defective for virus production and have shown resistance to lab and field strains of the avian leukosis virus through four generations. Ordinarily, the virus commands chicken cells to make more virus particles. But cells in the resistant birds make only the virus envelope, or empty shell surrounding the virus particle.



ARS animal geneticist and assistant check transgenic chickens maintained in isolation under a plastic canopy. (1185X1251—25)

Getting Soybeans To Grow

Geneticists have long since discovered that getting complex plants and animals to grow from single cells in lab dishes is not the simple, unvarying process it was once thought to be. For one thing, many of the genes in any cell of a complex organism are inactive except when they receive a specific stimulus—at certain developmental stages, for example. And strange things happen in the lab dish. Case in point: soybeans.

In the lab dish, a soybean cell's own genes for root and shoot development won't turn on. Without roots and shoots, obviously, there's no soybean plant. And without the ability to grow a whole organism from a genetically engineered cell, there's no point to genetic engineering. This is not an unusual phenomenon; root and shoot genes turn off in other plants too.

But for some plants, like alfalfa, tobacco, and petunias, scientists can just add synthetic hormones, and the roots and shoots develop. (This is one reason these three plants are commonly used in basic experiments with plant genetics.) With soybeans, though, synthetic hormones don't work.

So two ARS scientists at Beltsville, Maryland—a plant physiologist and a geneticist—teamed up to try a different approach to the problem. They knew that a soil organism called *Agrobacterium tumefaciens* causes tumors in plants by inserting genes for both root and shoot formation into the same cell—confusing the plant's growth mechanisms. The researchers inactivated the shoot-forming gene and let the bacterium infect soybean cells in the lab. The resulting root growth proved the technique was workable. Unfortunately, the reverse—inactivating the root-producing gene to get shoots to grow—didn't work in soybean cells. Similar difficulties have been overcome for peach trees (see p. 12), and the scientists are continuing to look for the key in soybeans.



Soybean cells in dish at left have grown roots after a soil organism, *Agrobacterium tumefaciens*, inserted root-producing genes into them. Without added genes, soybean cells grow into unorganized clumps (right). (0687X531-9)



Examining potato plant genetically engineered for insect resistance, ARS plant pathologist (top) finds little damage from Colorado potato beetles (bottom).
(0687X534-11/0687X533-22)

Protoplast Fusion

A plant cell wall inhibits exchange of material between cells. Stripping a plant cell of its wall leaves the protoplast, which can then be fused to another protoplast. Scientists use protoplast fusion to produce hybrids between species that cannot be bred conventionally.

Researchers at ARS labs in Beltsville, Maryland, and Philadelphia, Pennsylvania, used protoplast fusion to produce hybrid potato plants with insect resistance built into their leaves. The hybrids contain a rare gene for the insect-repelling chemical leptine, which was transferred into the plants from wild potatoes. Protoplast fusion was used because many wild and cultivated potatoes are sexually incompatible.

Biochemical Engineering

Biochemical engineering is one of the oldest biotechnologies. The biochemist manipulates plant and animal chemistry to make biological factories for everything from cheese and bread and beer and wine to industrial chemicals used in plastics, cosmetics, foods, feeds, detergents, inks, and hundreds of other products. Agrichemicals are important to reducing American dependence on foreign petroleum, and they provide an economically significant nonfood use for crops. In fact, biochemical engineering is a key to enhancing the desirability of American agricultural products both at home and abroad. One ARS project, for example, is to improve whey fermentation—a means to increase demand for dairy products and reduce surpluses. Another project is to improve enzyme production for manufacture of agrichemicals.

Yeast's expanding role as a biotech workhorse

Yeast, a simple one-celled fungus, is a biotechnology tool. It has been used for centuries to convert sugar into carbon dioxide, which makes bread rise, and into the alcohol essential to beer and wine. Yeasts are often used by the food industry in producing soups, soy sauce, and baby food. They are also used to break down lactose and starch, to treat industrial and agricultural waste, and to produce vitamin supplements and ethanol fuel. The ARS Northern Regional Research Center in Peoria, Illinois, maintains a research collection of 14,200 yeast strains. So far, not many of these strains are used commercially.

In the past, commercial interest in expanding the use of yeasts may have been held back by limited knowledge of their biochemistry. But research in the molecular biochemistry of yeasts has increased basic understanding of their metabolic processes to the point that scientists

are beginning to envision ways of creating marketable products inexpensively through fermentation, using genetically engineered yeasts.

From hundreds of yeast strains in the Peoria collection, researchers turned up four that could become modern biotechnology tools because they contain strings of DNA called linear plasmids. Currently, genetic engineers use circular plasmids as vehicles for transferring genes from one microorganism to another. In filamentous fungi, corn, and other higher plants, linear plasmids are surrounded by membranes of cell structures such as mitochondria and nuclei; these membranes are obstacles to successful gene transfer. Linear plasmids found in the four strains of yeast, on the other hand, replicate and float freely within the cell's inner space, or cytoplasm.

Linear plasmids have been found in one other yeast, *Kluyveromyces lactis*, by Japanese scientists. In 1986, British scientists used *K. lactis* linear plasmids to shuttle genes to another yeast in a successful gene transfer experiment. ARS geneticists and colleagues with the Biotechnology Research and Development Corporation of Peoria are carrying out similar experiments with the four Peoria yeast strains and are screening other yeasts in the collection for other plasmids to serve as possible biotech tools. Unlike *K. lactis*, which was already in commercial use before discovery of the linear plasmids, the four Peoria strains had no previously known economic potential.

Improving efficiency of commercial cucumber fermentations

During cucumber fermentation, bacteria used to convert sugars to lactic acid also produce carbon dioxide from malic acid of the cucumbers. Unless the carbon dioxide is purged from the fermenting brine, bloater damage (hollow cucumbers) can result. ARS researchers in Raleigh, North Carolina, have developed cultures of lactic acid bacteria that can't produce carbon dioxide from the malic acid. The scientists chemically mutated, selected, and improved strains of the bacterium, *Lactobacillus plantarum*, that had been isolated from commercial fermentations. ARS is cooperating with Chr. Hansen's Laboratory, of Milwaukee, which has been licensed to grow the new cultures to test feasibility of using them commercially. Pickle Packers International and its member companies have supported this research and are eager to use the new cultures.

The Plant Gene Expression Center

The Plant Gene Expression Center in Albany, California, was established in 1984 as a joint venture of the Agricultural Research Service, the University of California at Berkeley, and the California Agricultural Experiment Station. The center is in the San Francisco Bay area, a region that has one of the highest concentrations of plant genetic engineering research in the United States.

Research at the center is designed to provide new, precise, and much-needed information on exactly how plant genes are regulated, or expressed, in crop plants, on how instructions contained in a gene are executed by the plant. With this information and the tools of modern biotechnology, plant geneticists will be better able to isolate and transfer the genes that control agriculturally important traits. This research may also provide information critical to enhancing nonfood uses of the plant, such as improving the quality of the fiber or oils the plant provides.

Scientists at the center are engaged in several research projects that delve into the basic genetic mechanisms in plants. Two typical projects are—

- Learning how phytochrome controls genes. Phytochrome is a light-detecting molecule that was discovered in plants by ARS scientists some 35 years ago. It can be thought of as a powerful central switch that turns on genes that regulate some of the processes most vital to agriculture, including seed germination, flowering, and formation of chloroplasts (the structures in which photosynthesis takes place). Ability to regulate the activity of phytochrome could lead to increased energy production in the plant, which would increase its productivity.
- Studying the hormones and genes that regulate growth and aging in plants. Current research is concentrating on the growth-regulating hormone auxin, which in turn controls production of another hormone, ethylene. Ethylene causes fruit to ripen and eventually spoil. Almost 50 percent of the fresh fruits and vegetables harvested in the United States are eventually lost because of spoilage caused by ethylene. The long-term objective of this research is to be able to regulate the genes responsible for natural production of ethylene and therefore to control the ripening process.

Bioregulation

Bioregulators are chemicals, mainly hormones and enzymes, that control reproduction in insects and growth and development, behavior, reproduction, and metabolic functions such as photosynthesis in plants. ARS researchers are using several biotechnology tools in developing means to control and adjust some of these activities to improve plant and animal reproductive efficiency, tolerance to stress, growth rate, resistance to pests and diseases, control of pest insects, and timing of biological events such as fruit ripening and budbreak in fruit trees.

Typical of ARS bioregulation research are work on—

- Hormones governing brain/pituitary/gonad interrelationships in pigs; the objective is to adjust irregularities in swine reproductive cycles that are costly to farmers.
- Hormonal regulation of growth and development in plants. One such study is focusing on auxin, a growth-enhancing hormone. Another study is concentrating on the hormones that regulate development of wheat spikes and seed. Greater understanding of the genetic and biochemical factors involved in growth and development will lead to improved varieties.
- Hormonal regulation of insect reproduction and biochemistry of insect communication, chiefly the production of mating attractants. Disrupting their reproduction is a primary means of controlling insect pests. Other research focuses on the role of peptides as bioregulatory chemicals in livestock insects.
- The biochemical mechanisms of molecular transport across membranes—leading to an understanding of how sugars are moved from one part of a plant to another; ability to control these mechanisms will help improve quality and value of crop plants.
- Role of phytoalexins and other substances in resistance of citrus plants to nematodes. Phytoalexins are among the biologically active natural products that scientists are investigating as potential natural pesticides. Transferring the genes that govern manufacture of these products is a possible means of imparting this ability to other plants.
- Mechanisms that produce sterility in the progeny resulting from cross-breeding the tobacco budworm with a related species. Advances in this area of research may lead to the ability to induce male sterility in pest insect species (for which simple cross-breeding is impractical) via direct genetic intervention.

- Hormonal regulation of growth and development in pest insects (for example, the face fly and the corn earworm and tobacco budworm). One research project is focusing on synthesis of chitin, which forms the insect cuticle, or skeleton; disrupting this process would be an effective control measure.
- Microbial production of toxins (such as aflatoxins); aim is to find ways to mitigate this food-safety problem.
- Enzymes that govern photosynthetic carbon dioxide fixation so that the appropriate genetic factors can be included in breeding programs for increased crop productivity. Researchers also expect that the information gained in these studies will enable them to use genetic or biochemical engineering to modify the processes that limit photosynthetic rates.
- Regulation of photosynthetic carbohydrate metabolism in plants. The overall objective of this research is to increase the photosynthetic efficiency of economically valuable plants by manipulating the biochemical mechanisms that regulate starch/sucrose formation in leaves.
- The plant growth regulators abscisic acid, gibberellic acid, and jasmonic acid and enzymes that in turn regulate the regulators. Related research focuses on how light (especially photoperiod—the ratio of light to darkness in a given day) influences the development of flowering in plants. Understanding these regulatory mechanisms should lead to improved varieties.
- Biologically active natural products from microorganisms. These compounds, which are naturally occurring chemicals and are readily biodegradable, have a range of uses. Some function as herbicides, some as plant growth regulators. Others control organisms that cause plant diseases. Still others have potential as pharmaceuticals and insect-control agents.

Understanding bioregulation in plants

Several noteworthy recent advances in research on plant bioregulation have come from ARS labs.

- At Lubbock, Texas, scientists have made a key discovery about how plant enzymes respond to various temperatures. They found that the enzymes operate most efficiently within narrow temperature ranges called thermal kinetic windows. The temperature window varied among the five species studied—wheat, corn, cotton, spinach, and cucumbers. Field tests are continuing, and other enzymes will be studied. Transferring one plant's genes for controlling an enzyme's temperature response



In research on thermal kinetic windows, a factor in a plant's ability to tolerate heat and drought, an ARS plant physiologist uses an infrared thermometer to determine foliage temperatures of heat- and drought-stressed cotton plants. (88BW1520-10)

into other plants may change those plants' thermal kinetic windows. That could lead to new crop varieties that grow better at higher—or lower—temperatures than they do now.

- Studies in the lab at Aiea, Hawaii, have shown that when clusters of corn cells are subjected to too much salt or too little water, the cells will manufacture three proteins not found in other cells free of such stresses. Likewise, when corn seedlings were deprived of water, they reacted by synthesizing two other proteins that were not produced by their well-watered counterparts. Those two proteins rapidly disappeared when the plants were watered. If the genes that code for these proteins can be isolated, scientists hope to genetically engineer more tolerant varieties of corn as well as transfer the tolerance genes into other plants.
- Researchers at Urbana, Illinois, have isolated and cloned a gene responsible for the enzyme rubisco activase. This enzyme helps plants adjust to changes in light intensity during the first step in photosynthesis—converting atmospheric carbon dioxide to sugar. Now scientists can transfer modified versions of the cloned gene into chloroplasts (part of the plant cell that contains chlorophyll) to see which versions work best in different environments.

- Scientists at Raleigh, North Carolina, have purified and characterized the enzyme that determines oil content in soybeans and have produced the first soybean containing half the normal level of saturated fat. Research has also led to development of high-yielding high-protein soybeans. When these soybeans become commercially available, farmers will have a much-needed choice of which to grow—high-oil or high-protein varieties—depending on market conditions.
- Bringing genetic engineering of oilseed crops a step closer to reality is the synthesis by ARS scientists at Peoria, Illinois, of a gene that carries the blueprint for a key protein required for producing plant oil. The scientists have successfully inserted the new gene into a common bacterium, *Escherichia coli*. Once in the bacterium's genetic makeup, the gene directs production of acyl carrier protein. In plants, this protein is needed for several steps in the synthesis of fatty acids that are components of cell membranes and of oils stored in plant seed. Now enough of the protein can be made and purified to thoroughly study plant fatty acid synthesis. Forming the synthetic gene for acyl carrier protein was made easier by a new laboratory instrument called a DNA synthesizer, which links nucleotides into the proper sequence for construction of a particular gene. In followup work, the Peoria scientists have joined the gene for acyl carrier protein to a bacterial gene. This new gene has produced a fusion protein with properties of both the acyl carrier and bacterial proteins. Potential applications include improved methods for purifying other proteins used in oil production. Another possibility: If the engineered gene can be put into plants, the unique properties of the fusion protein could enable changes in plant oil production.
- At Beltsville, Maryland, two ARS plant pathologists have discovered that induced resistance to alfalfa anthracnose disease is controlled by specific genes. Scientists first found induced resistance in plants over 40 years ago and in alfalfa in 1984, but only lately have they been able to explain some of its mechanics. Molecules on a fungus that causes alfalfa anthracnose disease act like an antigen on an animal pathogen. These molecules—elicitors—trigger an antibodylike response in the plants. The plant pathologists have isolated the antifungal response compounds, which are called phytoalexins. Like antibodies, phytoalexins are not produced until infection occurs, and their production is ordered by certain genes. The alfalfa discovery has led the two scientists to develop the first rapid screening test to find and measure the effects of phytoalexins. They use pieces of

alfalfa tissue growing in laboratory dishes to trace the events of induced resistance. They want to know just how a plant recognizes that a disease organism is penetrating its surface. To find out, they are isolating the elicitors from the fungus and then using DNA probes to find the proper plant genes that respond to them. What studies of induced resistance in alfalfa reveal could lead to genetic engineering of many crops for strong, built-in defenses.

Bioregulation of human response to nutrients

Most ARS research on human nutrition is aimed at finding out how the body responds to and uses vitamins, minerals, and other nutrients. Working with rats, for example, scientists at the ARS Human Nutrition Research Center on Aging at Tufts in Boston have isolated the two genes that produce messenger RNA's that contain the information on how to make each of the subunit proteins of ferritin, the iron-storage protein. These two messenger RNA's also bear a sequence that repressor proteins bind to; the repressor proteins restrict the amount of ferritin being made when the cell is not receiving iron. When iron enters the cell, the repressor protein dissociates from the messenger RNA's, allowing them to make more ferritin to regulate the accumulation of iron. Further research is underway with the aim of eventually determining whether the accumulation of iron in the body contributes to the aging process in humans.



As part of studies on induced resistance in plants, ARS plant pathologist inoculates young alfalfa sprouts with a solution of harmful fungus spores. (0687X526-23)

Learn the latest status and emerging potential of pheromone applications in this comprehensive new study of...

Behavior-Modifying Chemicals for Insect Management

edited by

RICHARD L. RIDGWAY

*U.S. Department of Agriculture,
Agricultural Research Service,
Beltsville, Maryland*

ROBERT M. SILVERSTEIN

*State University of New York,
College of Environmental Science and Forestry,
Syracuse, New York*

MAY N. INSCOE

*U.S. Department of Agriculture,
Agricultural Research Service,
Beltsville, Maryland*

Applications of Pheromones and Other Attractants

*Contains contributions by
63 leading international
experts in entomology,
chemical ecology, and
agricultural chemistry!*

MARCEL DEKKER, INC.

270 Madison Avenue, New York, N.Y. 10016 • (212) 696-9000
Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland • Tel. 061/25 84 82

Behavior-Modifying Chemicals for Insect Management

March, 1990

760 pages, illustrated

\$195.00 (U.S. and Canada)

\$234.00 (All other countries)

SINCE their discovery in 1959, pheromones and other semiochemicals that mimic insects' sex attractants have opened up fundamental and applied research that has greatly expanded our knowledge of insect behavior and population dynamics. Many of the more than 1,000 identified pheromones and parapheromones have also proven of substantial practical use, holding the promise even of environmentally benign insect control.

Presenting an authoritative overview of the most current findings on pheromones, *Behavior-Modifying Chemicals for Insect Management* reviews the principles involved in employing these compounds . . . their chemistry . . . and delivery systems for efficient application. In addition, this volume discusses registration procedures in the U.S. and abroad as well as these chemicals' commercial development and availability.

Gives numerous case studies of current and potential practical uses against insects in horticultural crops, field crops, forestry, stored products, and insects affecting animals!

Complete with some 800 citations of related literature, this valuable reference

- describes the state of the art in pheromone applications—guiding workers in the field in these chemicals' most effective use
- furnishes detailed, accurate information on domestic and foreign regulation of pheromones—outlining the registration of behavioral chemicals in a convenient survey
- features an extensive table listing by order insects for which behavioral chemicals are available—including helpful entomological information as well as chemical names and commodities affected by the insect
- contains an international listing of commercial pheromone and related product suppliers—permitting easy access to materials for scientists and farmers

Behavior-Modifying Chemicals for Insect Management will serve as a definitive sourcebook for entomologists; agricultural, natural product, and biological chemists; chemical ecologists; plant and invertebrate pathologists; agronomists; pest management consultants; and advanced undergraduate and graduate students in these subjects.

C ONTENTS

Principles of Research and Development

Practical Use of Pheromones and Other Behavior-Modifying Compounds: Overview, *Robert M. Silverstein*

Principles of Monitoring, *Clive Wall*

Principles of Attraction—Annihilation: Mass Trapping and Other Means, *Gerald N. Lanier*

Principles of Mating Disruption, *Ring T. Cardé*

Chemical Analysis and Identification of Pheromones, *James H. Tumlinson*

Principles of Design of Controlled-Release Formulations, *Iain Weatherston*

Dispenser Design and Performance Criteria for Insect Attractants, *Barbara A. Leonhardt, Roy T. Cunningham, Willard A. Dickerson, Victor C. Mastro, Richard L. Ridgway, and Charles P. Schwalbe*

Olefin Metathesis as an Economical Route to Insect Pheromones, *Dennis S. Banasiak and James D. Byers*

Commercial Synthesis of Pheromones and Other Attractants, *Jeffrey J. Slocum*

The Research, Development, and Application Continuum, *B. Staffan Lindgren*

Pests of Horticultural Crops

Mating Disruption Technique to Control Codling Moth in Western Switzerland, *Pierre-Joseph Charmillot*

Oriental Fruit Moth in Australia and Canada, *Richard A. Vickers*

Mating Disruption of Oriental Fruit Moth in the United States, *Richard E. Rice and Philipp Kirsch*

Grape Berry Moth and Grape Vine Moth in Europe, *Charles Descoins*

Mating Disruption for Control of Grape Berry Moth in New York Vineyards, *Timothy J. Dennehy, Wendell L. Roelofs, Emil F. Taschenberg, and Theodore N. Taft*

Peachtree Borer and Lesser Peachtree Borer Control in the United States, *J. Wendell Snow*

The Male Lures of Tephritid Fruit Flies, *Roy T. Cunningham, Richard M. Kobayashi, and Doris H. Miyashita*

Development and Commercial Application of Sex Pheromone for Control of the Tomato Pinworm, *Jack W. Jenkins, Charles C. Doane, David J. Schuster, John R. McLaughlin, and Manuel J. Jimenez*

Forest Insect Pests

Use of Semiochemicals to Manage Coniferous Tree Pests in Western Canada, *John H. Borden*

Pheromones for Managing Coniferous Tree Pests in the United States, with Special Reference to the Western Pine Shoot Borer, *Gary E. Daterman*

Practical Use of Insect Pheromones to Manage Coniferous Tree Pests in Eastern Canada, *Chris J. Sanders*

Use of Disparlure in the Management of the Gypsy Moth, *Douglas M. Kolodny-Hirsch and Charles P. Schwalbe*

Pests of Field Crops

Application of the Sex Pheromone of the Rice Stem Borer Moth, *Chilo suppressalis*, *Sadabiro Tatsuki*

The Use of Pheromones for the Control of Cotton Bollworms and *Spodoptera* spp. in Africa and Asia, *Laurence J. McVeigh, Derek G. Campion, and Brian R. Critchley*

Use of Pink Bollworm Pheromone in the Southwestern United States, *Thomas C. Baker, Robert T. Staten, and Hollis M. Flint*

Role of the Boll Weevil Pheromone in Pest Management, *Richard L. Ridgway, Mary N. Inscocoe, and Willard A. Dickerson*

Population Monitoring of *Heliothis* spp. Using Pheromones, *Juan D. López, Jr., Ted N. Shaver, and Willard A. Dickerson*

Stored-Product Insect Pests and Insects Affecting Animals

Practical Use of Pheromones and Other Attractants for Stored-Product Insects, *Wendell E. Burkholder*

continued ►

CONTENTS (continued)

Use of Host Odor Attractants for Monitoring and Control of Tsetse Flies, *David R. Hall*

The Use of Pheromones and Other Attractants in House Fly Control, *Lloyd E. Browne*

Development, Registration, and Use

Commercial Development: Mating Disruption of the European Grape Berry Moth, *Ulrich Neumann*

Commercial Development: Mating Disruption of Tea Tortrix Moths, *Kinya Ogawa*

Pheromones: A Marketing Opportunity?, *Kurt Nabbolz*

Registration Requirements and Status for Pheromones in Europe and Other Countries, *Albert K. Minks*

Regulation of Pheromones and Other Semiochemicals in the United States, *Edwin F. Tinsworth*

Registration of Pheromones in Practice, *Charles A. O'Connor III*

Use of Pheromones and Attractants by Government Agencies in the United States, *Charles P. Schwalbe and Victor C. Mastro*

Commercial Availability of Insect Pheromones and Other Attractants, *May N. Inscoe, Barbara A. Leonhardt, and Richard L. Ridgway*

Prospects

Pheromones: Prophecies, Economics, and the Ground Swell, *Heinrich Arn*

Appendix: List of Commercial Suppliers

ISBN: 0-8247-8156-2

This book is printed on acid-free paper.



Credit Card and Purchase Orders Only
CALL TOLL-FREE 1-800-228-1160
Mon.-Fri., 8:00 a.m. to 4:30 p.m. (EST)
N.Y. State residents CALL 212-696-9000
or FAX your order to 914-796-1772

Mail today!

ORDER FORM

Mail to: **Promotion Dept., MARCEL DEKKER, INC.**
270 Madison Avenue, New York, N.Y. 10016

- ☐ Please send me _____ copy(ies) of ***Behavior-Modifying Chemicals for Insect Management*** edited by Richard L. Ridgway, Robert M. Silverstein, and May N. Inscoe at \$195.00 plus \$1.50 for postage and handling per volume. On prepaid orders and only \$.50 per volume.

I enclose payment in the amount of \$_____ by:

☐ check ☐ money order ☐ Visa ☐ MasterCard (4-digit interbank no. _____) ☐ Am. Exp.

Card No. _____ Exp. Date _____

Please bill my company: P.O. No. _____

Signature _____
(must be signed for credit card payment)

Name _____

Address _____

City/State/Zip _____

N.Y. residents must add appropriate sales tax. Prices are 20% higher outside the U.S. and Canada, and subject to change without notice.

Marcel Dekker, AG, Basel, bills in U.S. dollars at the United States export price. Payments are accepted in U.S. dollars or in Swiss francs at current day payment conversion rates. Domestic billings in Switzerland are in Swiss francs.



16.32
for dinner

WELCOME TO THE
ARS INSECT SEMIOCHEMICALS
WORKSHOP

The Management and Staff of Holiday Inn/Airport South welcomes the ARS Insect Semiochemicals Workshop personnel to our Inn. We are pleased to be hosting your group, and hope our facilities and services will provide you with a comfortable and enjoyable atmosphere.

In order to acquaint you with our facilities and services, we would like to provide you with the following information:

1. Complimentary van service is always available to and from the airport on a daily basis, 24 hours per day.
2. The new MARTA rail system operates an express train service to the downtown area. You can ride our van to the airport and the MARTA train is located directly inside the airport terminal. The cost is 85¢, providing you with a fast economical way to view the downtown attractions, including Underground Atlanta and Lenox Mall shopping.
3. There are several restaurants all within walking distance from the hotel. Below are some of these listed for your review:

LONGHORN STEAK HOUSE
STEAK 'N ALE
DUDLEY'S
SHONEY'S

FAST FOOD: Burger King, McDonald's, Waffle House, Wendy's
Pizza Hut, Pizza Inn, Arby's & Blimpie's

Please check at the Guest Services Desk or Front Desk in the lobby and our personnel will happily provide directions and additional information.

4. There are 7 movie theatres located just across the bridge over the interstate. They are listed in the paper as National 7.
5. Within the immediate area, there are several small shopping areas, from discount stores, grocery stores, to drug stores. A major shopping mall, Shannon Mall, is located 7 miles from the hotel. Again, please check with Guest Services and they will help you with additional information, directions, or transportation needs.

Holiday Inn Airport/South

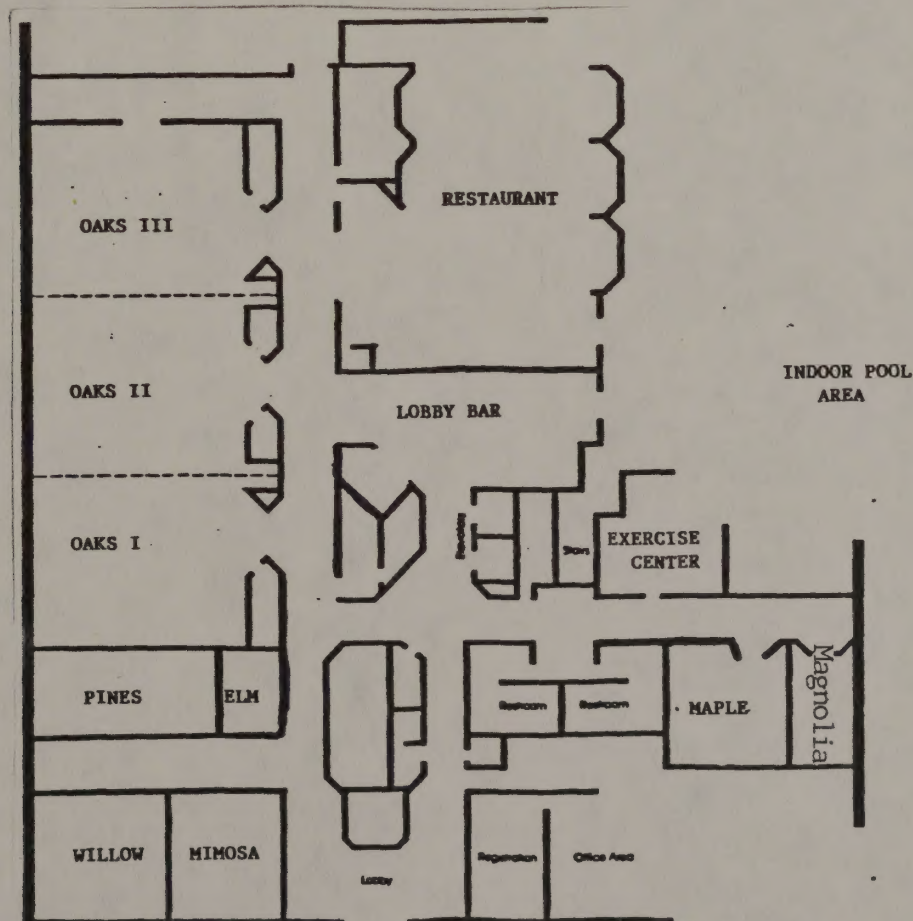
5010 Old National Highway • Atlanta, GA 30349 • Phone (404) 761-4000
OWNED AND OPERATED BY OLD NATIONAL INN, INC. UNDER LICENSE FROM HOLIDAY INNS, INC.

6. GENERAL INFORMATION ABOUT THE HOTEL

- Indoor/Outdoor Pools
- Exercise Room on Lobby Level
- Valet Service (Monday Through Friday, Drop off at Guest Services)
- Coin Operated Washer and Dryer on 7th floor in Vending Area Directly behind Elevators
- Lobby Bar Operates Daily from 3:00pm to 12:00am
- Evergreen Restaurant Operated Daily From 6:00am to 2:00pm and 5:00pm to 10:00pm Saturday and Sunday it opens at 7:00am.
- Complimentary coffee is available from 5am-6:30am at the Guest Services desk in the lobby. After 6:30am it is available in the Restaurant.
- Complimentary Van Service is provided to Shannon Mall (the closest major mall) twice each day. Check at Guest Services for schedule information.
- ESPN and WGN are complimentary in each room. Cable movies are available...Check the Movie Guide. These are free.

7. Should you need special assistance, we maintain a Manager on Duty 24 hours each day. Simply dial '0' and ask the operator to connect you.

8. If we have overlooked any information or services which you may need, please check at any time with our Guest Services or Front Desk staff and they will happily assist you.



Whitten

DRAFT
5/3/90

**INSECT SEMIOCHEMICALS:
OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE**

ARS Planning Workshop

Holiday Inn - Airport South
5010 Old National Highway
Atlanta, GA 30349
(404) 761-4000

May 7-10, 1990

Contents

Program Summary	2
Opening Session	3
Workshop I — Science	4
Workshop II — Technology	5
Workshop III — Applications	6
Closing Session	9
Committees	10

Agricultural Research Service

U. S. Department of Agriculture

INSECT SEMIOCHEMICALS: OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

Program Summary

Opening Session, Tuesday, May 8.

8:00 a.m. Welcome
 Objectives and Charge
 Needs for Alternative Methods of Insect Control
 Insect Chemistry
 Plant Chemistry
 Population Ecology
 Workshop Guidelines

Session A

Session B

Session C

Workshop I -- Science, Tuesday, May 8.

1:15 p.m.	1. Bioregulation	3. Chemistry (Insects)	5. Behavior
3:00 p.m.	2. Perception	4. Chemistry (Plants)	6. Population Dynamics

Workshop II -- Technology, Wednesday, May 9.

8:15 a.m.	1. Delivery Systems	3. Mass Trapping/ Baits	5. Semiochemicals (Plants)
10:15 a.m.	2. Monitoring	4. Mating Disruption	6. Semiochemicals (Beneficial Insects)

Workshop III -- Applications, Wednesday, May 9.

1:15 p.m.	1. Crops/Monitoring (Lepidoptera)	1. Crops/Monitoring and Suppression (Coleop.)	1. Animals (Acarina, Hymen., Dipt., Orthop.)
2:05 p.m.	2. Crops/Monitoring and Suppression (Lep.)	2. Crops/Feeding Deterrents (Lep., Col.)	2. Animals (Acarina, Hymen., Dipt., Orthop.) (contd.)
3:15 p.m.	3. Stored Products/ Monitoring (Lep., Coleop., etc.)	3. Crops/Monitoring and Suppression (Diptera: Tephritidae)	3. Beneficial Insects (Hymenoptera)
4:05 p.m.	4. Crops/Monitoring (Hemip., Homop., Hymenop., etc.)	4. Crops/Monitoring and Suppression (Diptera: Tephritidae) (contd.)	4. Beneficial Insects (Hymenoptera) (contd.)

*Reporters
need to be
identified*

Closing Session, Thursday, May 10.

8:00 a.m. Technology Transfer Opportunities
 Regulatory Considerations
 Summary Reports and Closing Remarks

12:35
 4:00 - Report committee

INSECT SEMIOCHEMICALS: OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

ARS Planning Workshop

May 7-10, 1990

Monday, May 7

Registration — Lobby

3:00-7:00 p.m.

Planning Meeting — Pine Room

7:30 p.m. Steering and Report Committees, Moderators, Reporters, and Co-Organizers

Tuesday, May 8

Registration — Outside Oak Room II

7:00-11:00 a.m.

Opening Session — Oak Room II

Moderator: J. Coppedge

8:00 a.m. Welcome - E. Corley

8:15 Objectives and Charge to the Workshop - R. Faust

8:30 Needs for Alternative Methods of Insect Control - M. Mellinger

*Ag consultant
in Fla & P.R.*

9:15 Insect Chemistry - R. Cardé

10:00 Break

Moderator: J. Lewis

10:15 Plant Chemistry - H. Cutler

11:00 Population Ecology - P. Price

11:45 Workshop Guidelines - R. Ridgway

12:00 noon Lunch

Workshop I - Semiochemical Science: Molecules, Organisms, and Populations
(additional discussants may be added)

Tuesday, May 8

Science A — Oak Room I

1:15 p.m.	Science A 1. Bioregulation	Introductory Paper: Moderator: Reporter: Discussants:	- A. Raina - J. Menn - H. Oberlander - L. Miller - P. Teal et al.
3:00	Break		
3:15	Science A 2. Perception	Introductory Paper: Moderator: Reporter: Discussants:	- J. Dickens - H. Oberlander - J. Menn - J. Klun - S. Meyer et al.
5:00	Adjourn		

Science B — Oak Room II

1:15 p.m.	Science B 3. Chemistry (Insects)	Introductory Paper: Moderator: Reporter: Discussants:	- J. Tumlinson - R. Heath - O. Chortyk - D. Carlson - R. Bartelt et al.
3:00	Break		
3:15	Science B 4. Chemistry (Plants)	Introductory Paper: Moderator: Reporter: Discussants:	- R. Flath - O. Chortyk - R. Heath - P. Hedin et al.
5:00	Adjourn		

Science C — Pine Room

1:15 p.m.	Science C 5. Behavior	Introductory Paper: Moderator: Reporter: Discussants:	- P. Landolt - J. McLaughlin - C. Rogers - A. Collins et al.
3:00	Break		
3:15	Science C 6. Population Dynamics	Introductory Paper: Moderator: Reporter: Discussants:	- E. Mitchell - C. Rogers - J. McLaughlin - J. Hayes et al.
5:00	Adjourn		

Pool Side

6:00 Attitude Adjustment

Oak Ballroom

7:30	Dinner Moderator Keynote Address	- R. Burns - L. Davis Univ. of Georgia
------	--	--

Workshop II - Technology: Approaches to Utilization
(additional discussants may be added)

Wednesday, May 9

Technology A — Oak Room I

8:15 a.m.	Technology A 1. Delivery Systems	Introductory Paper: Moderator: Reporter: Discussants:	- B. Leonhardt - L. McDonough - D. Hardee - R. Heath et al.
10:00	Break		
10:15	Technology A 2. Monitoring	Introductory Paper: Moderator: Reporter: Discussants:	- C. Schwalbe - R. Heath - B. Leonhardt - J. Lopez et al.
12:00 noon	Lunch		

Technology B — Oak Room II

8:15 a.m.	Technology B 3. Mass Trapping/Baits	Introductory Paper: Moderator: Reporter: Discussants:	- D. Lance - P. Teal - J. Payne - J. Smith et al.
10:00	Break		
10:15	Technology B 4. Mating Disruption	Introductory Paper: Moderator: Reporter: Discussants:	- J. Krysan - J. Payne - P. Teal - R. Staten - K. Thorpe et al.
12:00 noon	Lunch		

Technology C — Pine Room

8:15 a.m.	Technology C 5. Semiochemicals (Plants)	Introductory Paper: Moderator: Reporter: Discussants:	- G. Daterman - R. Flath - R. Gueldner - R. Severson et al.
10:00	Break		
10:15	Technology C 6. Semiochemicals (Beneficial Insects)	Introductory Paper: Moderator: Reporter: Discussants:	- J. Lewis - R. Jones - P. Greaney - R. Cardé et al.
12:00 noon	Lunch		

Workshop III --Applications: Opportunities and Needs for Expanded Use
(discussants may be added)

Wednesday, May 9

Applications A — Oak Room I

- | | | |
|-----------|---|---|
| 1:15 p.m. | Applications A
1. Crops/ Monitoring
(Lepidoptera) | *J. Klun
*C. Rogers
K. Elsey
E. Mitchell
J. McLaughlin |
| 2:05 | Applications A
2. Crops/ Monitoring and
Suppression (Lepidoptera) | *J. Krysan
*P. Lingren
T. Henneberry
W. Wolf |
| 2:55 | Break | |
| 3:15 | Applications A
3. Stored Products/ Monitoring
(Lepidoptera, Coleoptera, etc.) | *W. Burkholder
*R. Howard
J. Coffelt
K. Vick
M. Mullen
R. Mankin |
| 4:05 | Applications A
4. Crops/ Monitoring (Heteroptera,
Homoptera, Hymenoptera, etc.) | *J. Aldrich
*K. Elsey
W. Jones
J. Kamm
G. Snodgrass
J. Neal |
| 4:55 | Adjourn | |

* Co-Organizers: These persons have the option of making a brief introductory presentation; they will select discussants to make 5 minute presentations to serve as the basis of discussion, will designate a reporter to prepare a 1-2 page report, and will moderate the session.

Workshop III -- Applications: Opportunities and Needs for Expanded Use
(discussants may be added)

Wednesday, May 9

Applications B — Oak Room II

- | | | |
|-----------|--|--|
| 1:15 p.m. | Applications B
1. Crops/ Monitoring and
Suppression (Coleoptera) | *J. Coppedge
*D. Lance
Wm. Cantello
T. Ladd
J. Smith
R. Bartelt
M. Klein |
| 2:05 | Applications B
2. Crops/ Feeding Deterrents
(Lepidoptera, Coleoptera) | *J. Jenkins
*H. Cutler
P. Hedin
R. Gueldner
D. Warthen
N. Wakabayashi |
| 2:55 | Break | |
| 3:15 | Applications B
3. Crops/ Monitoring and
Suppression (Diptera,
Tephritidae) | *C. Calkins
*B. Leonhardt
R. Cunningham
P. Landolt
N. Wakabayashi
D. Robacker
D. Warthen
A. DeMilo
R. Heath
E. Jang
D. Light |
| 4:05 | Applications B
4. Crops/Monitoring and
Suppression (Diptera,
Tephritidae), contd. | (same as above) |
| 4:55 | Adjourn | |

* Co-Organizers: These persons have the option of making a brief introductory presentation; they will select discussants to make 5 minute presentations to serve as the basis of discussion, will designate a reporter to prepare a 1-2 page report, and will moderate the session.

Workshop III --Applications: Opportunities and Needs for Expanded Use
(discussants may be added)

Wednesday, May 9

Applications C — Pine Room

- | | | |
|-----------|--|---|
| 1:15 p.m. | Applications C
1. Animals (Acarina,
Hymenoptera, Diptera,
and Orthoptera) | *R. Patterson
*J. Whitten
L. Hammack
R. Vander Meer
D. Carlson
A. DeMilo
R. Brenner |
| 2:05 | Applications C
2. Animals (Acarina,
Hymenoptera, and
Diptera), contd. | (same as above) |
| 2:55 | Break | |
| 3:15 | Applications C
3. Beneficial Insects (Hymenoptera) | *J. Lewis
*J. Tumlinson
R. Jones
P. Greany
A. Collins
Wm. Nettles |
| 4:05 | Applications C
4. Beneficial Insects (Hymenoptera)
(contd.) | (same as above) |
| 4:55 | Adjourn | |

* Co-Organizers: These persons have the option of making a brief introductory presentation; they will select discussants to make 5 minute presentations to serve as the basis of discussion, will designate a reporter to prepare a 1-2 page report, and will moderate the session.

Wednesday, May 9

- 6:00 Dinner (on your own)
- 7:30 Preparation of Summary Reports

Thursday, May 10Closing Session — Oak Room II

Moderator: R. Ridgway
Reporter: M. Inscoe

- 8:00 a.m. Technology Transfer Opportunities - Richard Parry
- Industrial Representatives Panel
- Owen Jones
 - AgriSense
 - Staffan Lindgren
 - PheroTech
 - Philip Kirsch
 - BioControls Ltd.
 - Charles Doane
 - Scentry
- 9:00 Regulatory Considerations
- Guidelines for ARS Scientists - Richard Parry
 - Opportunities for Improving the Process - Anne Lindsay
 - Perspectives from the Forest Service - EPA
 - Perspectives from the Private Sector - Max Ollieu
 - FS
 - Ian Weatherston
 - Tech. Services
 - Group
- 10:15 Break

Moderator: R. Faust

10:30 a.m. Summary Reports

Science

- Bioregulation / Perception
- Chemistry
- Behavior / Population Dynamics

J. Menn

~~O. Chortyk~~ Heath

C. Rogers

Technology

- Delivery Systems / Monitoring
- Mass Trapping / Mating Disruption
- Semiochemicals

~~R. Heath~~ Leonhardt

~~J. Payne~~ Tenl

~~J. Krysan~~ Flath

Opportunities and Needs for Problem Solving

- Crop Pests
- Stored Product Pests
- Man and Animal Pests
- Beneficial Insects

J. Coppedge

W. Burkholder

R. Patterson

J. Tumlinson

Discussion

Closing Remarks

12:30 p.m. Adjourn

Committees — Oak Room II

1:30 Steering and Report Committees Meeting

INSECT SEMIOCHEMICALS: OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

ARS Planning Workshop

Steering Committee

R. Ridgway
Beltsville, MD

J. Lewis
Tifton, GA

R. Heath
Gainesville, FL

W. Snow
Byron, GA

R. Flath
Albany, CA

R. Patterson
Gainesville, FL

J. Coppedge
Beltsville, MD

R. Faust
Beltsville, MD

Report Committee

R. Faust
Beltsville, MD

J. Coppedge
Beltsville, MD

H. Oberlander
Gainesville, FL

R. Ridgway
Beltsville, MD

R. Patterson
Gainesville, FL

J. Krysan
Yakima, WA

C. Rogers
Tifton, FL

R. Flath
Albany, CA

B. Leonhardt
Beltsville, MD

J. Lewis
Tifton, GA

Registration and Local Arrangements Committee

W. Snow
Byron, GA

J. Coppedge
Beltsville, MD

R. Mayhew
Beltsville, MD

D. Hyde
Athens, GA

THE FAR SIDE GARY LARSON

ARS PLANNING WORKSHOP

INSECT SEMIOCHEMICALS:

OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

OR

INSECT SEMIOCHEMICALS AND OTHER BEHAVIOR MODIFIERS:

OPPORTUNITIES AND CONSTRAINTS

OR

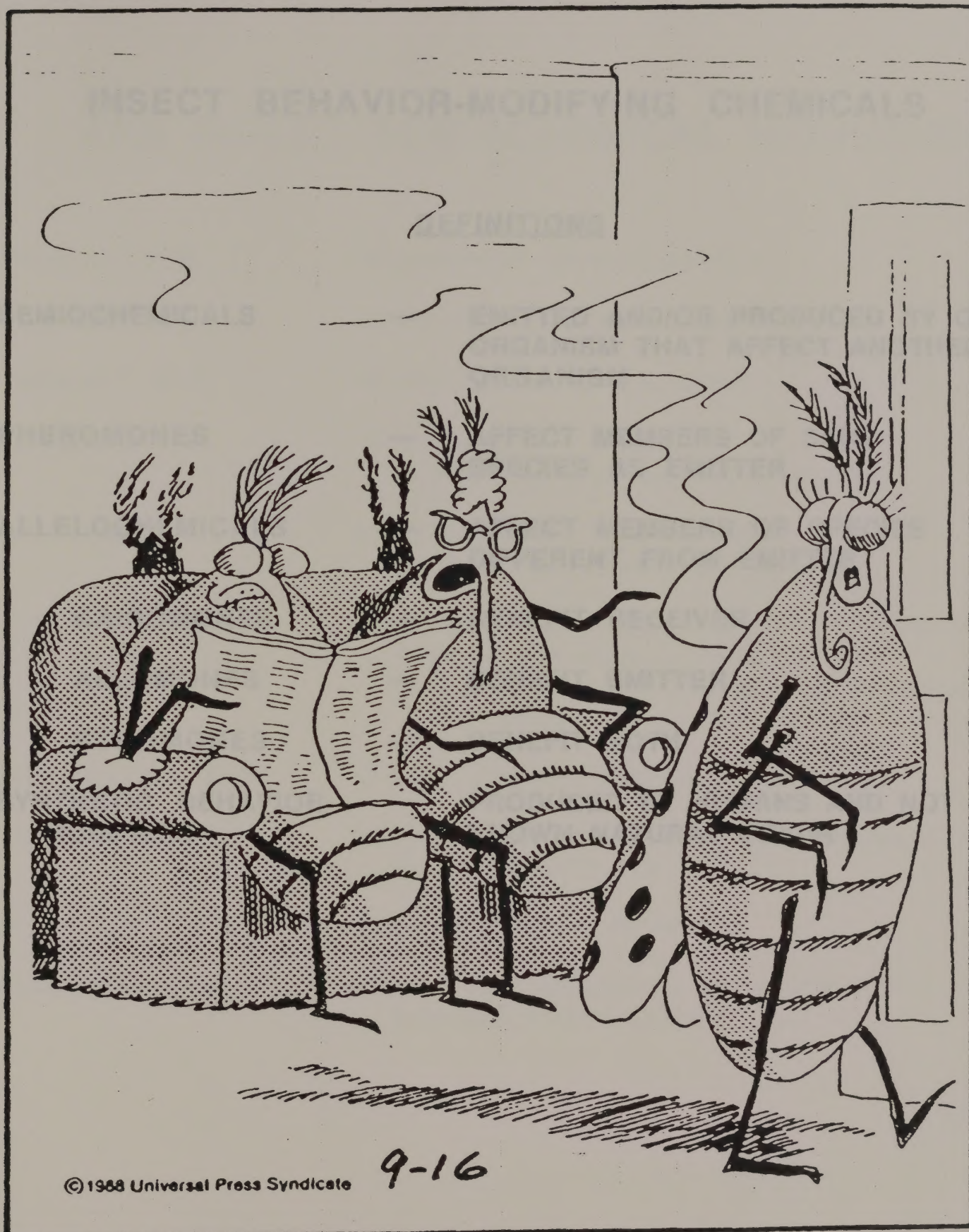
INSECT BEHAVIOR-MODIFYING CHEMICALS:

OPPORTUNITIES AND NEEDS

OR

???

THE FAR SIDE GARY LARSON



"Hold it right there, young lady! Before you go out, you take off some of that makeup and wash off that gallon of pheromones!"

INSECT BEHAVIOR-MODIFYING CHEMICALS

DEFINITIONS

SEMIOCHEMICALS	—	EMITTED AND/OR PRODUCED BY ONE ORGANISM THAT AFFECT ANOTHER ORGANISM
PHEROMONES	—	AFFECT MEMBERS OF SAME SPECIES AS EMITTER
ALLELOCHEMICALS	—	AFFECT MEMBERS OF SPECIES DIFFERENT FROM EMITTER
KAIROMONES	—	BENEFIT RECEIVER
ALLOMONES	—	BENEFIT EMITTER
SYNOMONES	—	BENEFIT BOTH
SYNTHETIC BEHAVIOR MODIFIERS	—	PRODUCED BY HUMANS AND NOT OF KNOWN NATURAL ORIGIN

ARS INSECT SEMIOCHEMICAL WORKSHOP

- MONDAY EVE. WORKSHOP COORDINATION**
- TUESDAY A.M. OPENING SESSION / OVERVIEW**
- TUESDAY EVE. RECEPTION AND BANQUET**
- TUESDAY P.M. WORKSHOP I - SCIENCE**
(6 topics in 3 concurrent sessions)
- WEDNESDAY A.M. WORKSHOP II - TECHNOLOGY**
(6 topics in 3 concurrent sessions)
- WEDNESDAY P.M. WORKSHOP III - APPLICATIONS: OPPORTUNITIES**
AND NEEDS FOR EXPANDED USE
(9 topics, 3 double time periods, 3 concurrent sessions)
- WEDNESDAY EVE. OPEN / REPORT PREPARATION**
- THURSDAY A.M. TECHNOLOGY TRANSFER AND REGULATORY**
CONSIDERATIONS
- SUMMARY ORAL REPORTS**
- THURSDAY P.M. COMMITTEE MEETINGS TO COORDINATE**
REPORT PREPARATION

ARS INSECT SEMIOCHEMICAL WORKSHOP

- **INDIVIDUALS HAVE BEEN DESIGNATED TO BE RESPONSIBLE FOR LEADING WORKSHOP SESSIONS**
- **CORE PRESENTERS AND DISCUSSANTS HAVE BEEN IDENTIFIED**
- **ALL PARTICIPANTS WERE PROVIDED AN OPPORTUNITY TO MAKE A FIVE-MINUTE PRESENTATION**
- **PARTICIPANTS WISHING TO MAKE PREPARED PRESENTATIONS NOT LISTED ON PROGRAM SHOULD CONTACT MODERATORS OR ORGANIZERS PRIOR TO THE SESSION**
- **AMPLE DISCUSSION TIME FOR EXCHANGE OF INFORMATION AND IDEAS HAS BEEN ALLOWED**
- **OBSERVERS WHO WISH TO LISTEN BUT NOT PARTICIPATE SHOULD DRIFT TO REAR OF MEETING ROOMS**
- **BE PREPARED TO IDENTIFY OPPORTUNITIES AND NEEDS. FEEL FREE TO WRITE THEM OUT FOR MODERATORS AND REPORTERS**
- **BRIEF WRITTEN REPORTS WILL BE PREPARED ON EACH SESSION**
- **SUMMARY ORAL REPORTS WILL BE GIVEN TO ENTIRE GROUP**

INSECT SEMIOCHEMICAL WORKSHOP: WRITTEN REPORTS

Session	Responsible Individuals	Length (pages)	Report Committee Contact
<u>Opening</u>	Oberlander/Krysan	2	Oberlander
<u>Science</u>			
A. Bioregulation/Perception	Menn/Oberlander	2	Faust
B. Chemistry	Heath/Chortyk	2	Flath
C. Behavior/Population Dynamics	McLaughlin/Rogers	2	Rogers
<u>Technology</u>			
A. Delivery Systems/ Monitoring	Heath/Hardee	2	Leonhardt
B. Mass Trapping/Mating Disruption	Payne/Teal	2	Ridgway
C. Semiochemicals	Gueldner/Greaney	2	Krysan
<u>Applications</u>			
A1. Crops (Lepidoptera)	Klun/Rogers	1	Rogers
A2. Crops (Lepidoptera)	Krysan/Lingren	1	Krysan
A3. Stored Products	Burkholder/Howard	1	Patterson
A4. Crops (Heteroptera, etc.)	Aldrich/Elsey	1	Ridgway
B1. Crops (Coleoptera)	Coppedge/Lance	1	Coppedge
B2. Crops/Feeding Deterrents	Jenkins/Cutler	1	Flath
B3-4. Crops (Tephritidae)	Calkins/Leonhardt	1-2	Coppedge
C1-2. Animals	Patterson/Hammack	1-2	Patterson
C3-4. Beneficial Insects	Lewis/Tumlinson	1-2	Lewis
<u>Closing</u>	Inscoe/Ridgway	2	Faust

INSECT SEMIOCHEMICALS: OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

Outline for ARS Workshop Report

Table of Contents
Executive Summary
Workshop Highlights
Needs for Alternative Methods of Insect Management
Mission
Objectives and Process
Science Overview

Science

- Bioregulation
- Perception
- Chemistry (Insects)
- Chemistry (Plants)
- Behavior
- Population Dynamics

Technology

- Delivery Systems
- Monitoring
- Mass Trapping/Baits
- Mating Disruption
- Allelochemicals (Plants)
- Allelochemicals (Beneficial Insects)

Problem Solving Opportunities

- Crops
 - + Lepidoptera (moths)
 - + Coleoptera (beetles)
 - + Heteroptera, etc. (true bugs, etc.)
 - + Tephritidae (fruit flies)
 - + Insect deterrents
- Stored Products
- Humans and Animals
- Beneficial Insects

Technology Transfer

Regulatory Considerations

Appendices

- Definitions
- Program
- List of Participants
- Individual Scientists (separate volume)

DRAFT
5/2/90

INSECT SEMIOCHEMICAL WORKSHOP: FORMAT FOR WRITTEN REPORTS

SESSION _____ REPORTER _____

Introduction:

Selected ARS Accomplishments:

Current Research:

Research Opportunities and Needs:

INSECT SEMIOCHEMICAL WORKSHOP: ORAL REPORTS

Thursday, May 10, 1990, 10:30 a.m.—12:30 p.m.

Topic	Responsible Individual	Length
<u>Science</u>		
A. Bioregulation/Perception	Menn	10 min
B. Chemistry	Chortyk	10 min.
C. Behavior/Population Dynamics	Rogers	10 min.
<u>Technology</u>		
A. Delivery Systems/ Monitoring	Heath	10 min.
B. Mass Trapping/Mating Disruption	Payne	10 min.
C. Semiochemicals	Krysan	10 min.
<u>Needs and Opportunities for Problem Solving</u>		
Crop Pests	Coppedge	15 min.
Stored Product Pests	Burkholder	10 min.
Man and Animal Pests	Patterson	10 min.
Beneficial Insects	Tumlinson	10 min.

Insect Semiochemicals Workshop
Partial List of Insect Opportunities

Grasshoppers	Whiteflies
<i>Heliothis</i> and <i>Helicoverpa</i>	Flies (humans and animals)
Boll weevil	Wasps
Corn rootworm	Bees
Fruit flies	Loopers
Fire ant	Exotics
Hemiptera (<i>Lygus</i> et al.)	Codling moth
Gypsy moth	European cornborer
Pink bollworm	Cutworms
Colorado potato beetle	Stem borers
Tree borers	Stored product moths
<i>Spodoptera</i>	Stored product beetles
Ticks	Diamondback moth
Aphids	Mexican bean beetle
Scales	Cockroaches
Cereal leaf beetle	Leaf miners

Semiochemicals and Insect Population Dynamics:

Opportunistic Dilemma

Everett R. Mitchell¹

How Pheromones Are Used

Sex attractant pheromones have been proclaimed throughout the world as having great potential for managing insect pests through manipulation of mating behavior; annihilation by mass trapping; and as monitoring and survey tools that facilitate control through early detection of pests allowing for the timely application of appropriate control measures, including pesticides. While much has been written on these topics and some notable progress has been made, most would agree that the highly touted potential for these powerful behavior modifiers has yet to be fully realized.

The most common application of sex pheromones has been as survey tools to: monitor adult emergence cycles and relative changes in population densities; provide early warning and estimates of the potential for movement of insect pests among cropping systems within an area; and to detect the migration of insects from known or suspected inoculum sites into regions normally free of the pest. The use of sex attractants as predictive tools to forecast pest numbers or potential damage levels in specific crops during the growing season has experienced limited success.

Factors Impeding Development of Model Systems

The paucity of substantial and dramatic success in the use of sex attractant pheromones to describe and quantify the dynamics of pest

insect populations can be attributed to many factors. The fact that the attractant often is directed at only one sex, generally males, is especially significant. Other factors complicating the acquisition and interpretation of data, especially trap captures, include the effects of differences in pheromone blends, component ratios, and formulations; trap design; sex specific differences in habits or activity patterns at different times of the day or night; pheromone production and responsiveness to sex attractants at different times of the cropping season under changing environmental conditions and varying population levels; controlled and uncontrolled changes in the microclimate associated with cropping and cultural practices; general climatic patterns and the effects of weather fronts on insect transport; the diversity, availability, distribution and maturity of host plants; the type and abundance of natural enemies and pathogens; and the presence or absence of competing species.

Few species have been so thoroughly characterized.

Old Ideas Revisited

The vast majority of attractant chemicals identified have been sex specific pheromones, primarily produced by females and attractive to males. Effective attractants-sex, food, oviposition-for females of the species would greatly enhance opportunities for using semiochemicals to manage insect pest

populations. Recent research has confirmed what has long been suspected--females use a number of cues, including chemical volatiles, to locate plants on which to feed, mate, and oviposit. Identification of plant constituents or other compounds that directly affect the female's feeding or reproductive behavior will enhance greatly the capacity of researchers to define, quantify, and model the biological and environmental events controlling the establishment, development, and dispersal of insect pests. Chemical attractants for females also have broad implications for control of insect pests.

Opportunities for Future Research

1. Accelerate present efforts and develop new initiatives to identify chemicals that modify female behavior.
2. Determine the role of wild plant hosts--including species diversity, abundance, succession, physiological condition, and phenology--in the reproductive processes of pest insects.

Special emphasis should be given to naturally-occurring chemicals that influence: host selection and colonization; pheromone production; calling behavior; and responses to sex, food, and other attractants.

3. Continue striving to develop model systems for indexing insect populations in time and space using trap captures and other data generated from behavioral responses of females and males to attractant sources.
4. What role do semiochemicals (insect or plant) play in insect dispersal?

¹ ARS USDA Workshop "Insect Semiochemicals: Opportunities and Constraints for Development and Use; Session C, Population Dynamics." May 8, 1990.

ARS INSECT SEMIOCHEMICAL WORKSHOP
Atlanta, Georgia
May 7-10, 1990

Dr. Jeffrey Aldrich
USDA/ARS/BA
Bldg 467, BARC-EAST
Beltsville, MD 20705

Dr. Mike Banfield
Consep Membranes Inc.
P.O. Box 6059
Bend OR. 07708

Dr. Robert Bartelt
USDA/ARS/MWA
1815 N. University
Peoria, IL 61604

Dr. R Bartlett
Fermon Chemicals Inc.
1700 N. 7th Ave.Suite 100
Phoenix, AZ 85007

Dr. Keith Bramley
Micro Flo. Co.
P.O. Box 5948
Lakeland, Fl 33807

Dr. Richard Brenner
USDA/ARS/SAA
1700 SW 23RD DR
P.O. Box 14565
Gainesville, FL 32604

Dr. David Brown
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr Wendell Burkholder
USDA/ARS/MWA
1925 Linden Dr., West
Madison, WI 53706

Dr. Robert Burns
USDA/ARS/SAA
P. O. Box 5677
Athens, GA 30613

Dr. Carrol Calkins
USDA/ARS
1700 S.W. 23rd Drive
Gainesville, FL 32604

Dr. Bruce Campbell
USDA/ARS
Western Regional Res. Ctr.
800 Buchanan Street
Albany, CA 94710

Dr. William Cantelo
USDA/ARS/BA
Bldg 004, BARC-WEST
Beltsville, MD 20705

Dr. Ring Carde
Dept. of Entomology
Univ. of Massachusetts
Amherst, MA 01003

Dr. David Carlson
USDA/ARS
P.O. Box 14565
Gainesville, FL 32604

Dr. Orestes Chortyk
Tob.Qual.&Safety Res.Unit
P.O. Box 5677
Athens, GA 30613

Dr. James Coffelt
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Anita Collins
USDA/ARS
2413 E. Highway 83
Bldg. 205
Weslaco, TX 78596

Dr. John Cook
AgriSense
4230 West Swift, Suite 106
Fresno, CA 93722

Dr. James Coppedge
USDA/ARS/NPS
Bldg 005, Rm 212,
Beltsville, MD 20705

Dr. E. Corley, Jr.
USDA/ARS/SAA
P. O. Box 5677
Athens, GA 30613

Dr. Horace Culter
USDA/ARS/SAA
P. O. Box 5677
Athens, GA 30613

Dr. Roy Cunningham
USDA/ARS
P.O. Box 4459
Hilo, HI 96720

Dr. G. Daterman
Forest Sciences Lab.
3200 S.W. Jefferson Way
Corvallis, OR 97331

Dr. L. Davis
Dept of Entomology
Univ of Georgia
Athens, GA 30602

Dr. Albert DeMilo
USDA/ARS/BA
Room 10, Bldg 010
Beltsville, MD 20705

Dr. Joseph Dickens
USDA/ARS/MSA
P. O. Box 5367
Mississippi State, MS 39762

Dr. C. Doane
26405 Weat Highway 85
P.O. Box 426
Buckeye, AZ 85326

Dr. Robert Doolittle
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Pat Dowd
USDA/ARS/MWA
1815 N. University
Peoria, IL 61604

Dr. Fred Eller
ARS
Peoria, IL

Dr. Kent Elsey
U. S. Vegetable Lab.
2875 Savannah Highway
Charleston, SC 29414

Dr. Gary Elzen
USDA/ARS/MSA
Delta State Res. Ctr.
P. O. Box 346
Stoneville, MS 38776

Dr. Kenneth Farminer
AgriSense
4230 west Swift, Suite 106
Freson, CA 93722

Dr. Robert Faust
USDA/ARS/NPS
Bldg 005, Rm 232
Beltsville, MD 20705

Dr. Steven Ferkovich
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Robert Flath
USDA/ARS
Western Regional Res. Ctr.
800 Buchanan Street
Albany, CA 94710

Dr. Patrick Greany
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. T Green
Pest Management Supply
P.O. Box 938
Amherst, MA 01004

Dr. R. Gueldner
USDA/ARS/RRC
Tob.Qual.& Safety Res.Unit
P.O. Box 5677
Athens, GA 30613

Dr. Dennis Hamel
USDA Forest Service
12th and Independent, S.W.
P.O. Box 96090
Washington, D.C. 20090-6090

Dr. Leslie Hammack
USDA/ARS/NPA
Bioscience Research Lab
P.O. Box 5674
Fargo, ND 58105

Dr. Dick Hardee
USDA/ARS/MSA
P. O. Box 346
Stoneville, MS 38776

Dr. Jane Hayes
USDA/ARS/MSA
P. O. Box 346
Stoneville, MS 38776

Dr. Robert Heath
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Paul Hedin
USDA/ARS
Boll Weevil Research Lab.
P.O. Drawer 5367
Mississippi State, MS 39762

Don Hendricks
USDA/ARS
Cotton Insects Res.
Stoneville, MS 38776

Thomas Henneberry
USDA, ARS, PWA
4135 E. Broadway Road
Phoenix, AZ 85040

Dr. Ralph Howard
U.S. Grain Mktg. Res.Lab
1515 College Ave.
Manhattan, Kansas 66502

Dr. Franklin Howell
USDA/ARS
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr. May Inscoe
USDA/ARS/BA
Room 205, Bldg. 402
Beltsville, MD 20705

Dr. Eric Jang
USDA/ARS/PWA
P.O. Box 4459
Hilo, HI 96720

Dr. Johnie Jenkins
USDA/ARS/MSA
P. O. Box 5367
Mississippi State, MS 39762

Dr. Walker Jones
Carl Hayden Bee Res. Ctr.
2000 E. Allen Rd.
Tucson, AZ 85719

Dr. O. Jones
AgriSense-BCS Ltd
Mid Glamorgan, UK

Dr. Richard Jones
Dept. Of Entomology
Univ. of Minnesota
1980 Fowell Ave
St Paul, MN 55108

Dr. James Kamm
USDA/ARS/PWA/NFSPRC
Oregon State Univ.
3450 S.W. Campus Way
Corvallis, Oregon 97333

Dr. John Kennedy
John W. Kennedy Consultants
9101 Cherry Ln., Suite 113
Laural, MD 20708-1133

Dr. Philipp Kirsh
Biocontrol LTD
719 Second St. Suite 12
Davis, CA 95616

Dr. Michael Klein
USDA/ARS/MWA
Ohio Agri.Lab/Hort.Ins.Lab.
Wooster, OH 44691

Dr. J. Klun
USDA/ARS
Room 203, Bldg. 309
Beltsville, MD 20705

Dr. Alan Knight
USDA/ARS
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr. James Krysan
USDA/ARS
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr. Thyrl Ladd, Jr.
USDA/ARS/MWA
Ohio Agri. Ctr./Hort.Ins.Lab.
Wooster, OH 44691

Dr. David Lance
USDA/ARS/NPA
RR 3
Brookings, SD 57006

Dr. Peter Landolt
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Barbara Leonhardt
USDA/ARS/BA
Room 165, Bldg. 011A
Beltsville, MD 20750

Dr. Joe Lewis
USDA/ARS
P.O. Box 748
Tifton, GA 31793

Dr. Y.-S. Li
USDA/ARS/MWA
P.O. Box 7629
Research Park, Route K
Columbia, MO 65205

Dr. Douglas Light
USDA/ARS/PWA
800 Buchanan Street
Albany, CA 94710

Dr. Peter Lingren
USDA/ARS/SPA
Hwy 3, West
Lane, OK 74555

Dr. S. Lindgren
Phero Tech Inc.
1140 Clark Dr.
Vancouver, B.C.
Canada V5L #K3

Dr. Anne Lindsay
Environmental Prot. Agency
401 M Street., S.W.-H7505
Washington, DC 20460

Dr. William Lingren
Trece Inc.
645 South Sanborn Rd.
P.O. Box 5267
Salinas, CA 94901

Dr. Juan Lopez
USDA/ARS/SPA/A&M Univ.
Rm 231, Ag Eng. Bldg.
College Station, TX 77843

Dr. Robert Lynch
USDA/ARS/SAA
P. O. Box 748
Tifton, GA 31793

Dr. Richard Mankin
USDA/ARS/IABBBRL
1700 S.W. 23rd Drive
Gainesville, FL 32604

Dr. V. Mastro
USDA APHIS
Otis AFB
Otis MA 02542

Dr. Sidney Mayer
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Heather McAulane
Dept. of Entomology
Texas A & M
College Station
TX 77843-2475

Dr. Les McDonough
USDA/ARS
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr. John McLaughlin
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Madeline Mellinger
Glades Crop Care
949 Turner Quay
Jupiter, FL 33458

Dr. Julius Menn
USDA/ARS/BA
Bldg 003, BARC-WEST
Beltsville, MD 20705

Dr. Steve Miller
USDA/ARS/IABBBRL
P. O. Box 14565
Gainesville, FL 32604

Dr. Lois Miller
Dept of Entomology
Univ of Georgia
Athens, GA 30602

Dr. Everett Mitchell
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. D. Mueller
Insects Limited Inc.
P.O. Box 40641
10505 N. College Ave.
Indianapolis, IN 46280

Dr. Michael Mullen
USDA/ARS
Stored-Product Ins.R&D Lab.
P.O. Box 22909
Savannah, GA 31403

Dr. John Neal, Jr.
USDA/ARS
Bldg. 470
Beltsville, MD 20705

Dr. William Nettles, Jr.
USDA/ARS
2301 S. International Blvd.
Weslaco, TX 78596

Dr. Herbert Oberlander
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Max Ollieu
USDA Forest Service
12th and Independent, S.W.
P.O. Box 96090
Washington, D.C. 20090-6090

Dr. Richard Parry
USDA/ARS/OCI
Bldg. 005, Rm. 102
Beltsville, MD 20705

Dr. Richard Patterson
USDA/ARS/SAA
P. O. Box 14565
Gainesville, FL 32604

Dr. Jerry Payne
USDA/ARS/SAA
P. O. Box 87
Byron, GA 31008

Dr. Peter Price
Dept. of Biology
Northern Arizona Univ.
Flagstaff, AZ 86001

Dr. Burt Quisumbing
Hercon Environmental Co.
P.O. Box 786
York, PA 17405

Dr. Ashok Raina
USDA/ARS/BA
Room 101, Bldg. 402
Beltsville, MD 20705

Dr. Richard Rice
Kearney Agri. Ctr.
Univ. of California
Parlier, CA 93648

Dr. Richard Ridgway
USDA/ARS/BA
Room 107, Bldg. 402
Beltsville, MD 20705Dr.

Dr. David Robacker
USDA/ARS
2301 S. International Blvd.
Weslaco, TX 78596

Dr. Charlie Rogers
USDA/ARS/IBPMRL
P.O. Box 748
Tifton, GA 31793-0748

Dr. R. Schalk
U. S. Vegetable Lab.
2875 Savannah Highway
Charleston, SC 29414

Dr. W. Schlotzhauer
USDA/ARS/RRC
Tob.Qual.&Safety Res.Unit
P.O. Box 5677
Athens, GA 30613

Dr. C. Schwalbe
USDA APHIS
Otis AFB
Otis MA 02542

Dr. Ray Severson
USDA/ARS/RRC
Tob.Qual.&Safety Res.Unit
P.O. Box 5677
Athens, GA 30613

Dr. M. Shannon
USDA APHIS PPQ
Federal Bldg.
6505 Belcrest Rd.
Hyattsville, MD 20782

Dr. John Sivinski
USDA/ARS
1700 S.W. 23rd Drive
Gainesville, FL 32604

Dr. Mike Smith
USDA/ARS/SAA
P. O. Box 87
Bryon, GA 31008

Dr. James Smith
USDA/ARS/MSA
P. O. Box 5367
Miss. State, MS 39762

Dr. Gordon Snodgrass
USDA,ARS,MSA
Delta Station Research
P.O Box 346
Stoneville, MS 38776

Dr. Maurice Snook
USDA/ARS/RRC
Tob.Qual. & Safety Res. Unit
P.O. Box 5677
Athens, GA 30613

Dr. Wendell Snow
USDA/ARS/SAA
P. O. Box 555
Watkinsville, GA 30677

Dr. R. Spaide
USDA APHIS PPQ
Federal Bldg.
6505 Belcrest Rd.
Hyattsville, MD 20782

Dr. R. Staten
USDA APHIS PPQP
4125 E. Broadway
Phoenix, AZ 85040

Dr. William Steiner
USDA/ARS/MWA
P.O. Box 7629
Research Park, Route K
Columbia, MO 65205

Dr. Peter Teal
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Walter Tedders, Jr.
USDA/ARS/SAA
P. O. Box 87
Bryon, GA 31008

Dr. K Thorpe
USDA/ARS/BA
Room 101, Bldg. 402
Beltsville, MD 20705

Dr. Frederic Tingle
USDA/ARS
P.O. Box 14565
Gainesville, FL 32604

Dr. James Touhey
Office of Pesticide Prog.
U.S. E.P.A.
H7506C, Room 710, CM-2
Washington, D.C. 20460

Dr. J. Tumlinson
USDA/ARS/IABBBRL
P.O. Box 14565
Gainesville, FL 32604

Dr. Thomas Unruh
USDA/ARS/PWA
3706 W. Nob Hill Blvd.
Yakima, WA 98902

Dr. Robert Vander Meer
USDA/ARS/SAA
P. O. Box 14565
Gainesville, FL 32604

Dr. Kenneth Vick
USDA/ARS/IABBBRL
P. O. Box 14565
Gainesville, FL 32604

Dr N. Wakabayashi
USDA/ARS/BA
Room 206, Bldg 309
Beltsville, MD 20705

Dr. J. Warthen, Jr.
USDA/ARS/BA
Room 122, Bldg. 001
Beltsville, MD 20705

Dr. Iane Weatherston
Technology Services Group
1625 K Street N.W.

Suite 375
Washington D.C. 20006

Dr. James Whitten
USDA/ARS
P.O. Box 3149
Laredo, TX 78044

DRAFT
4/5/90

Conf. # 50 621 08136

404 761 4000
Dick Patterson
John George

INSECT SEMIOCHEMICALS:
OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPMENT AND USE

ARS Planning Workshop

Opening Session, Tuesday, May 8.

8:00 a.m. Welcome
Objectives and Charge
Needs for Alternative Methods of Insect Control
Insect Chemistry
Plant Chemistry
Population Ecology
Workshop Guidelines

Airport
Holiday Inn
South
Atlanta
May 8-9-10

800 - 465 4329

Session A

Session B

Session C

Workshop I -- Science, Tuesday, May 8.

1:15 p.m.	1. Bioregulation	3. Chemistry (Insects)	5. Behavior
3:00 p.m.	2. Perception	4. Chemistry (Plants)	6. Population Dynamics

Workshop II -- Technology, Wednesday, May 9.

8:15 a.m.	1. Delivery Systems	3. Mass Trapping/ Baits	5. Semiochemicals (Plants)
10:15 a.m.	2. Monitoring	4. Mating Disruption	6. Semiochemicals (Beneficial Insects)

Workshop III -- Applications, Wednesday, May 9.

1:15 p.m.	1. Crops/Monitoring (Lepidoptera)	1. Crops/Monitoring and Suppression (Coleop.)	1. Animals (Acarina, Hymen., Dipt., Orthop.)
2:05 p.m.	2. Crops/Monitoring and Suppression (Lep.)	2. Crops/Feeding Deterrents (Lep., Col.)	2. Animals (Acarina, Hymen., Dipt., Orthop.) (contd.)
3:15 p.m.	3. Stored Products/ Monitoring (Lep., Coleop., etc.)	3. Crops/Monitoring and Suppression (Diptera: Tephritidae)	3. Beneficial Insects (Hymenop.: Apoidea)
4:05 p.m.	4. Crops/Monitoring (Hemip., Homop., Hymenop., etc.)	4. Crops/Monitoring and Suppression (Diptera: Tephritidae) (contd.)	4. Beneficial Insects (Hymenop., Ichneumonoidea, etc.)

Closing Session, Thursday, May 10.

8:00 a.m. Technology Transfer Opportunities
Regulatory Considerations
Summary Reports and Closing Remarks

Whitten

ARS SEMIOCHEMICAL WORKSHOP
Atlanta, GA
May 7-10, 1990

